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(12) **United States Patent**
Hawarden et al.

(10) **Patent No.: US 10,473,542 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **SYSTEM, METHOD, AND APPARATUS FOR OPERATING A HIGH EFFICIENCY, HIGH OUTPUT TRANSMISSION**

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(73) Assignee: **EATON CUMMINS AUTOMATED TRANSMISSION TECHNOLOGIES, LLC**, Galesburg, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/663,235**

(22) Filed: **Jul. 28, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/438,201, filed on Dec. 22, 2016, provisional application No. 62/465,024, filed on Feb. 28, 2017.

(51) **Int. Cl.**
G01L 3/10 (2006.01)
B62D 6/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01L 3/105*** (2013.01); ***B62D 6/10*** (2013.01); ***F16H 37/0853*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . G01L 3/105; F16H 37/0853; F16H 61/0403; F16H 59/14; F16H 59/46;
(Continued)

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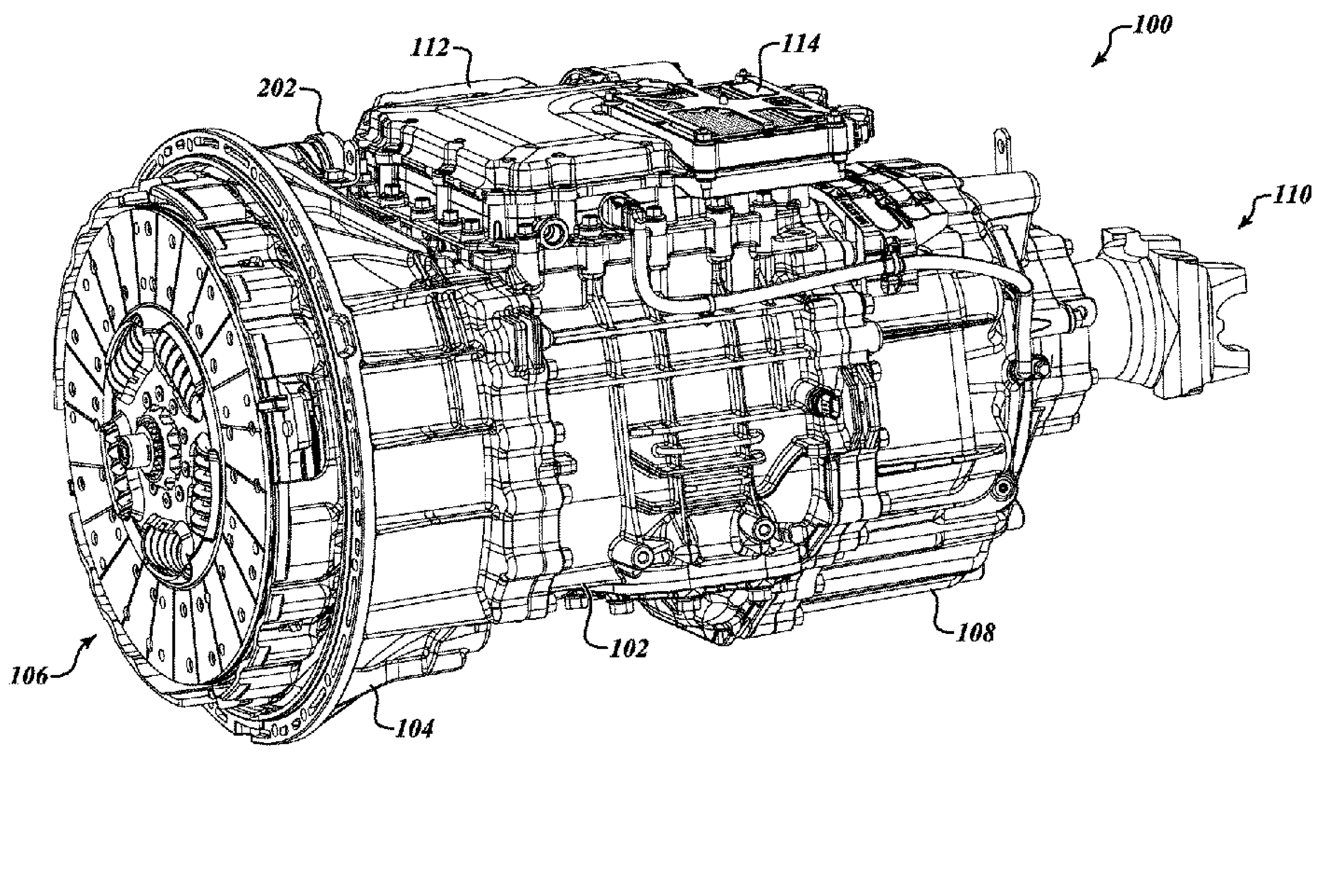
Primary Examiner — Octavia Hollington
(74) *Attorney, Agent, or Firm* — Walter Haverfield LLP; James J. Pingor

(57) **ABSTRACT**

A transmission includes an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing torque output to a driveline. A controller determines a shaft displacement angle representing an angle value of rotational displacement difference between at least two shafts of the transmission, and performs a transmission operation responsive to the shaft displacement angle.

20 Claims, 53 Drawing Sheets



(51) **Int. Cl.**

F16H 37/08	(2006.01)
F16H 61/04	(2006.01)
F16H 47/04	(2006.01)
F16H 59/14	(2006.01)
F16H 59/46	(2006.01)

(52) **U.S. Cl.**

CPC ***F16H 61/0403*** (2013.01); *F16H 59/14* (2013.01); *F16H 59/46* (2013.01); *F16H 2037/0873* (2013.01); *F16H 2037/0893* (2013.01); *F16H 2047/045* (2013.01); *F16H 2059/144* (2013.01)

(58) **Field of Classification Search**

CPC F16H 2037/0873; F16H 2037/2037; F16H 2037/0893; F16H 2037/2047; F16H 2037/045; F16H 2059/144; F16H 2047/045; B62D 6/10

USPC 73/862.331

See application file for complete search history.

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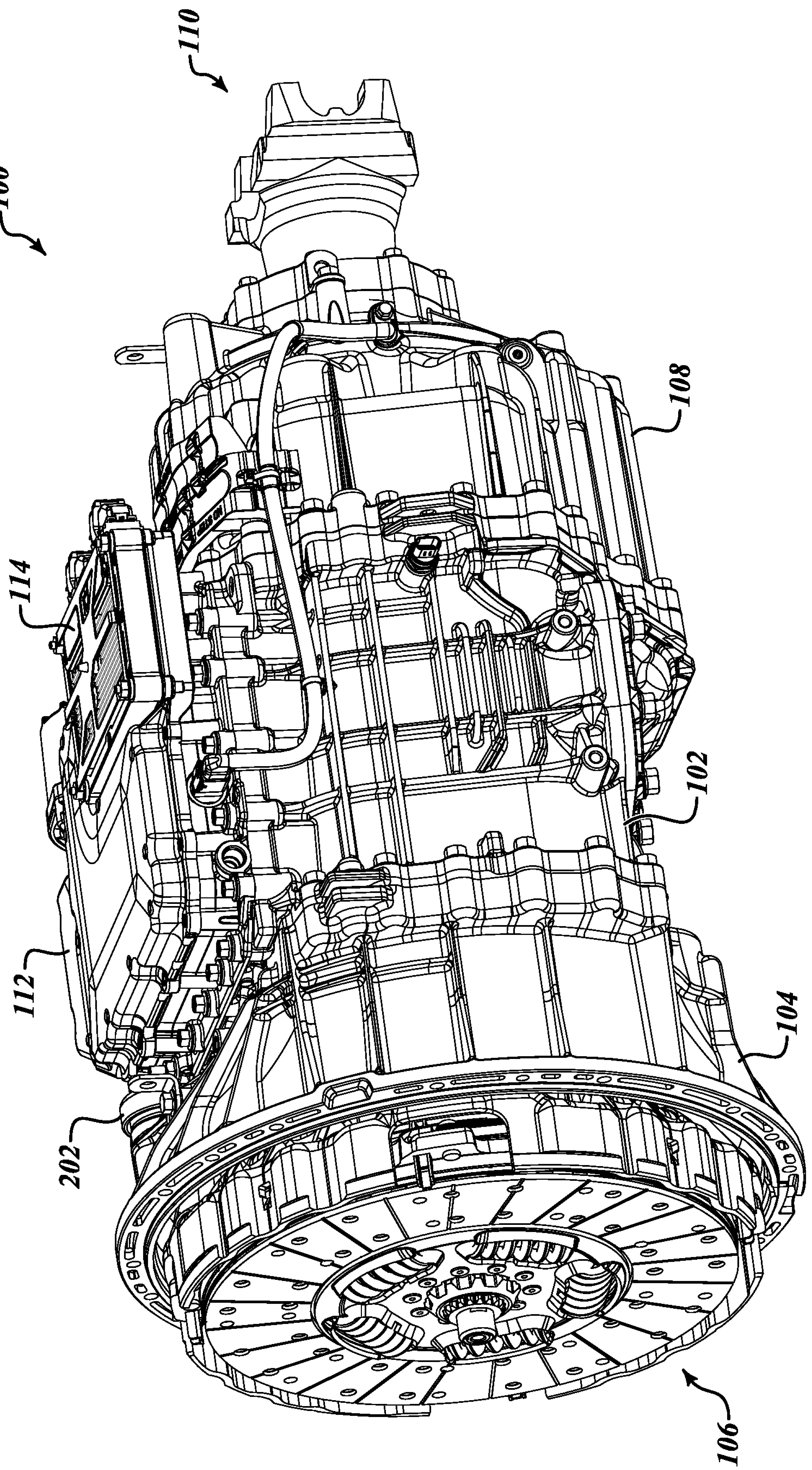
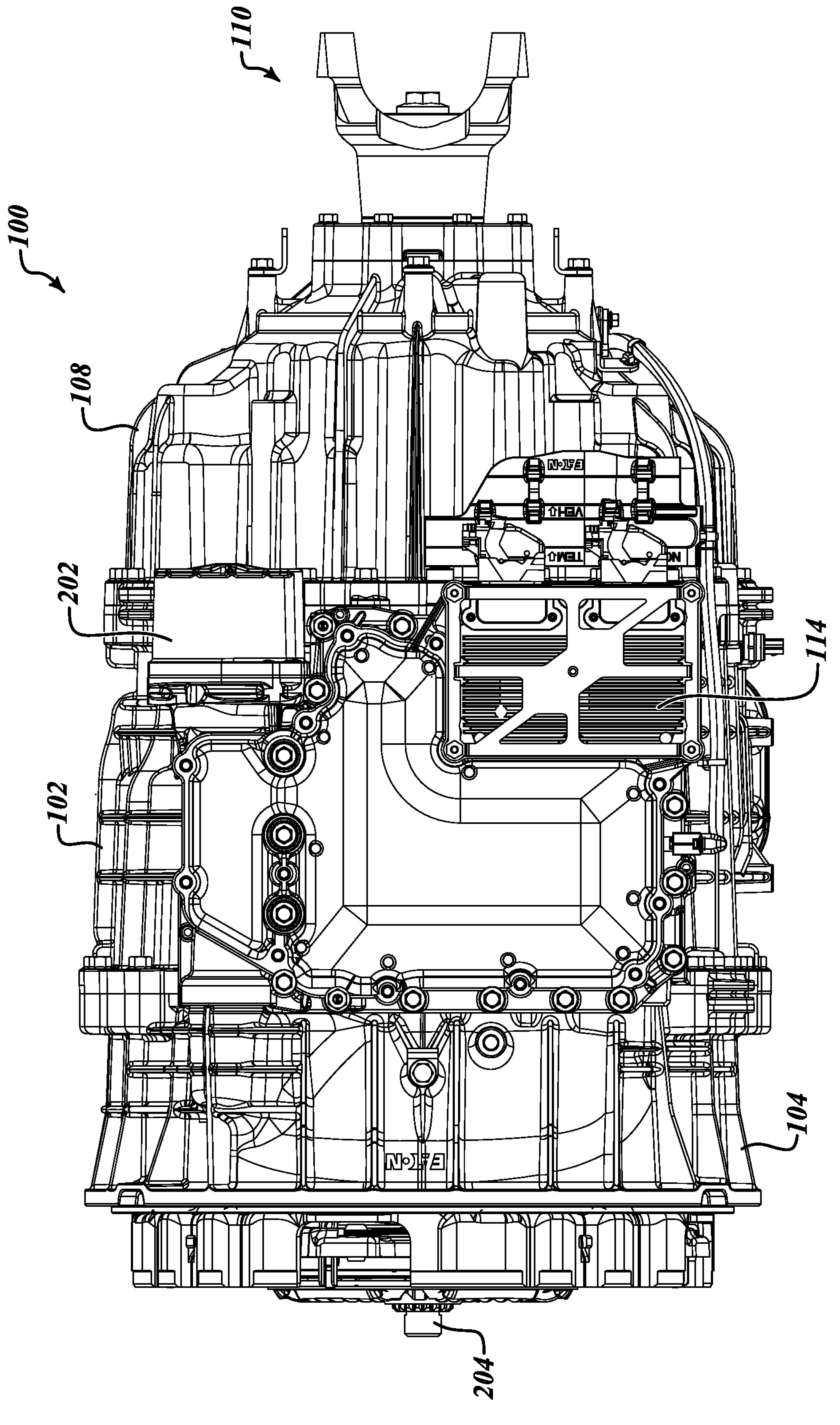


FIG. 1



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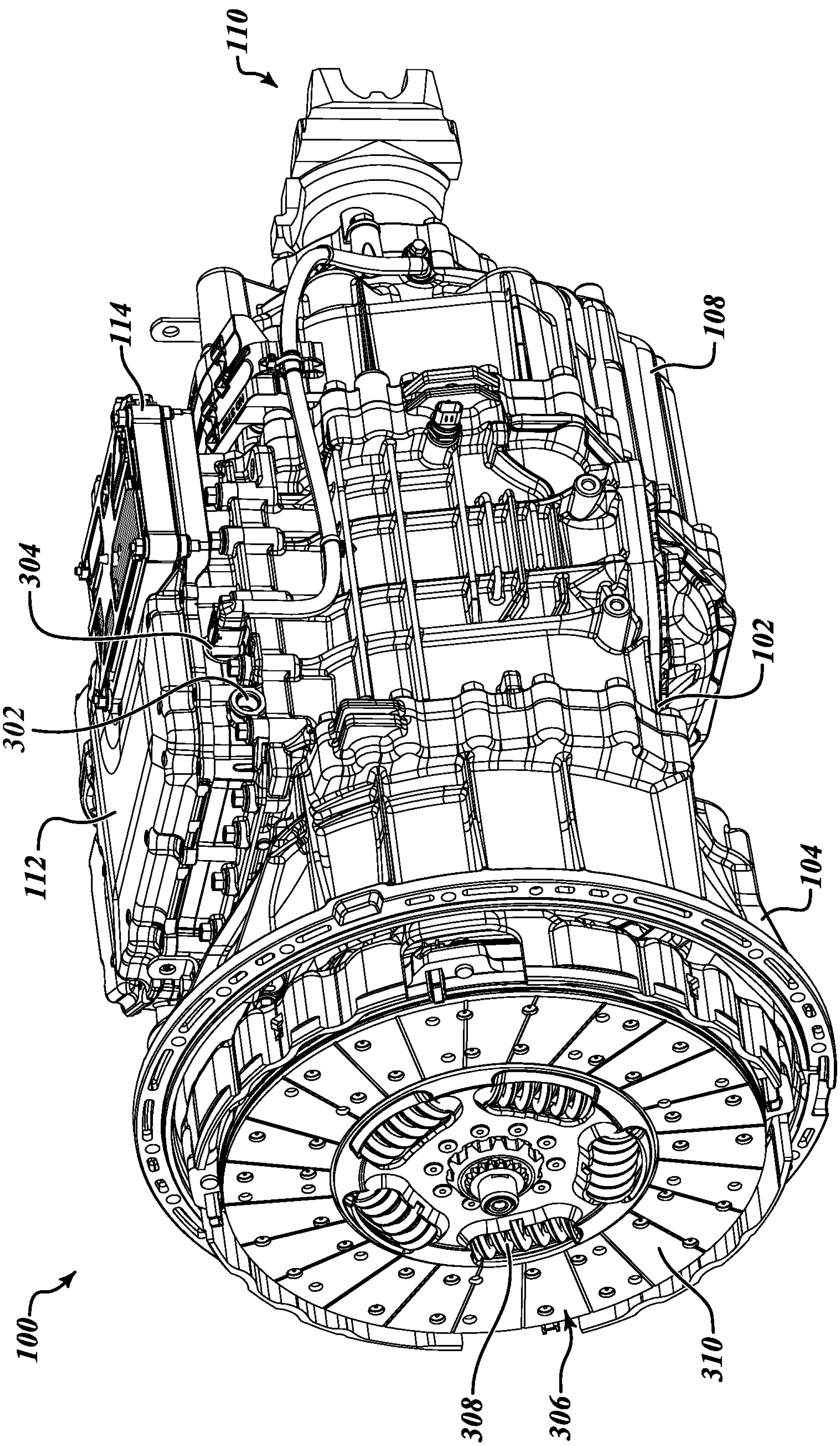

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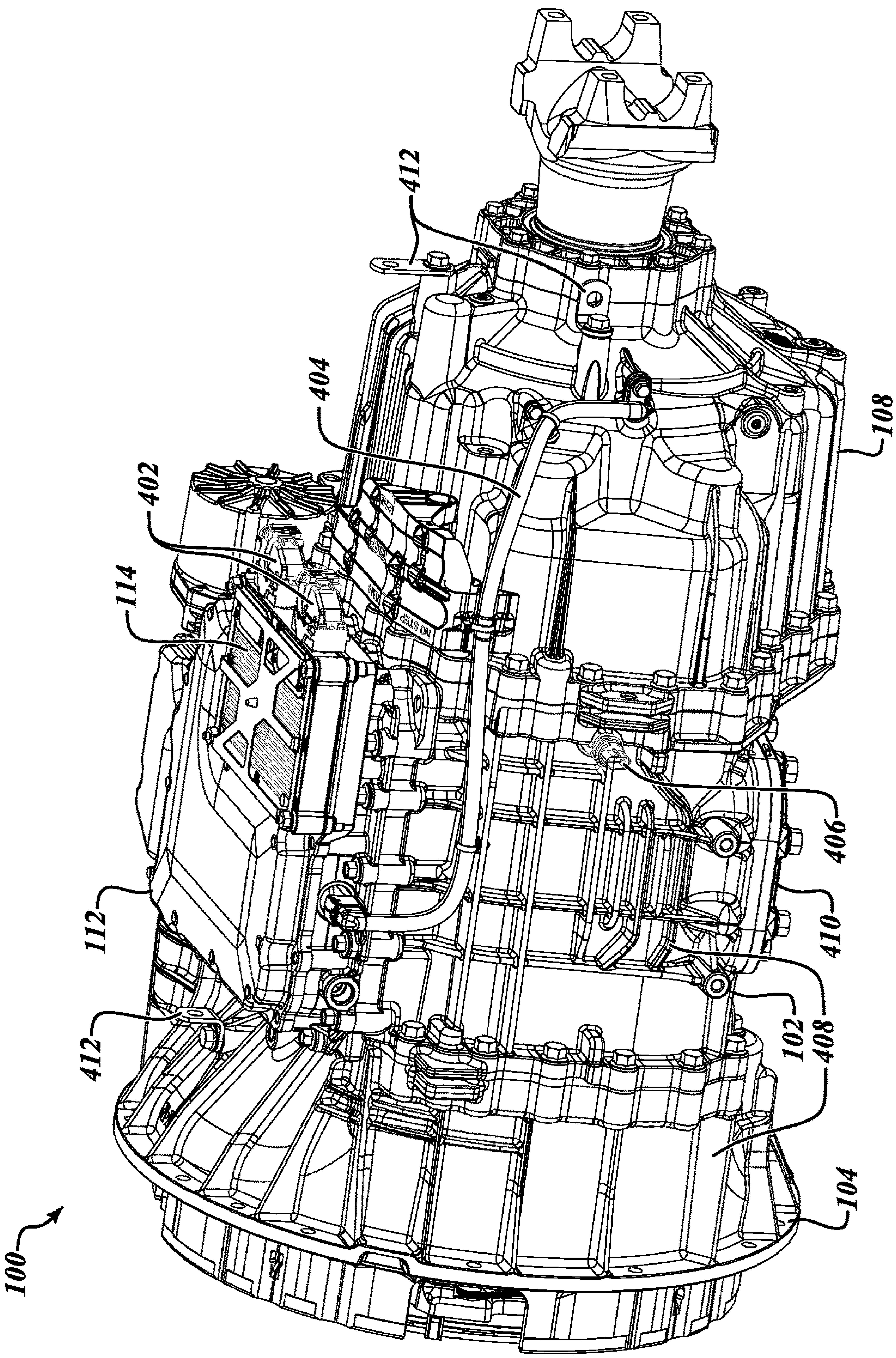

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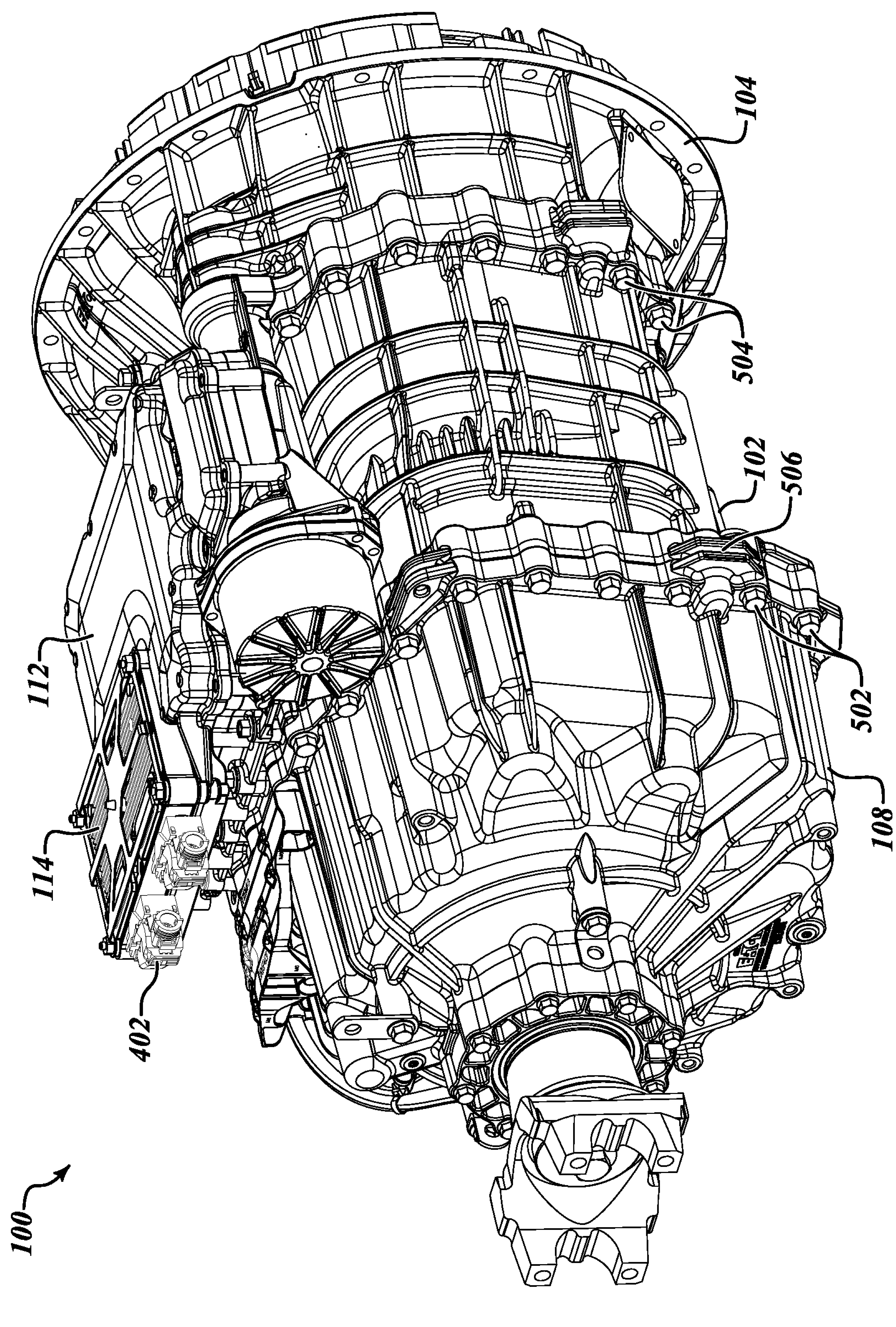

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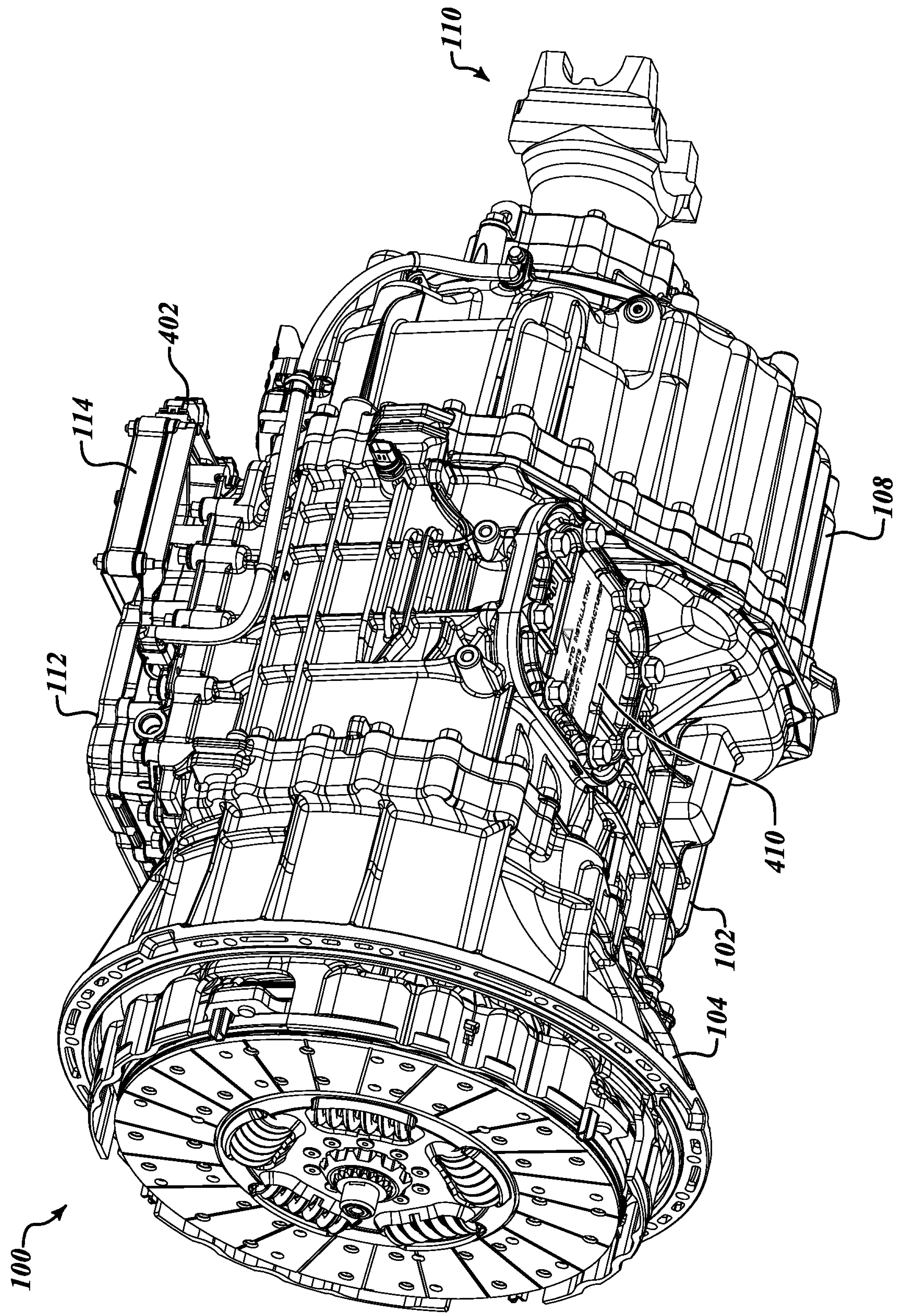

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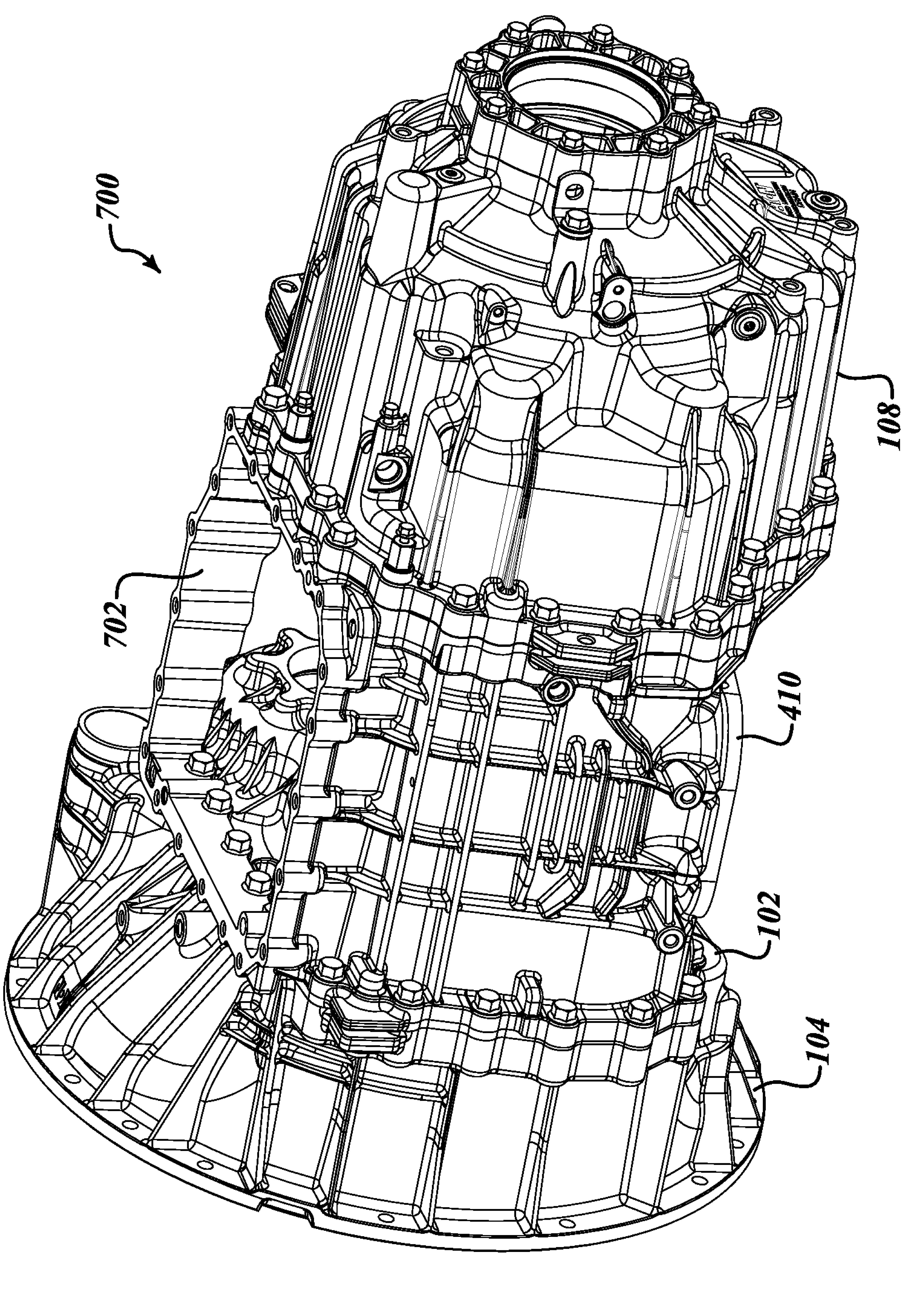

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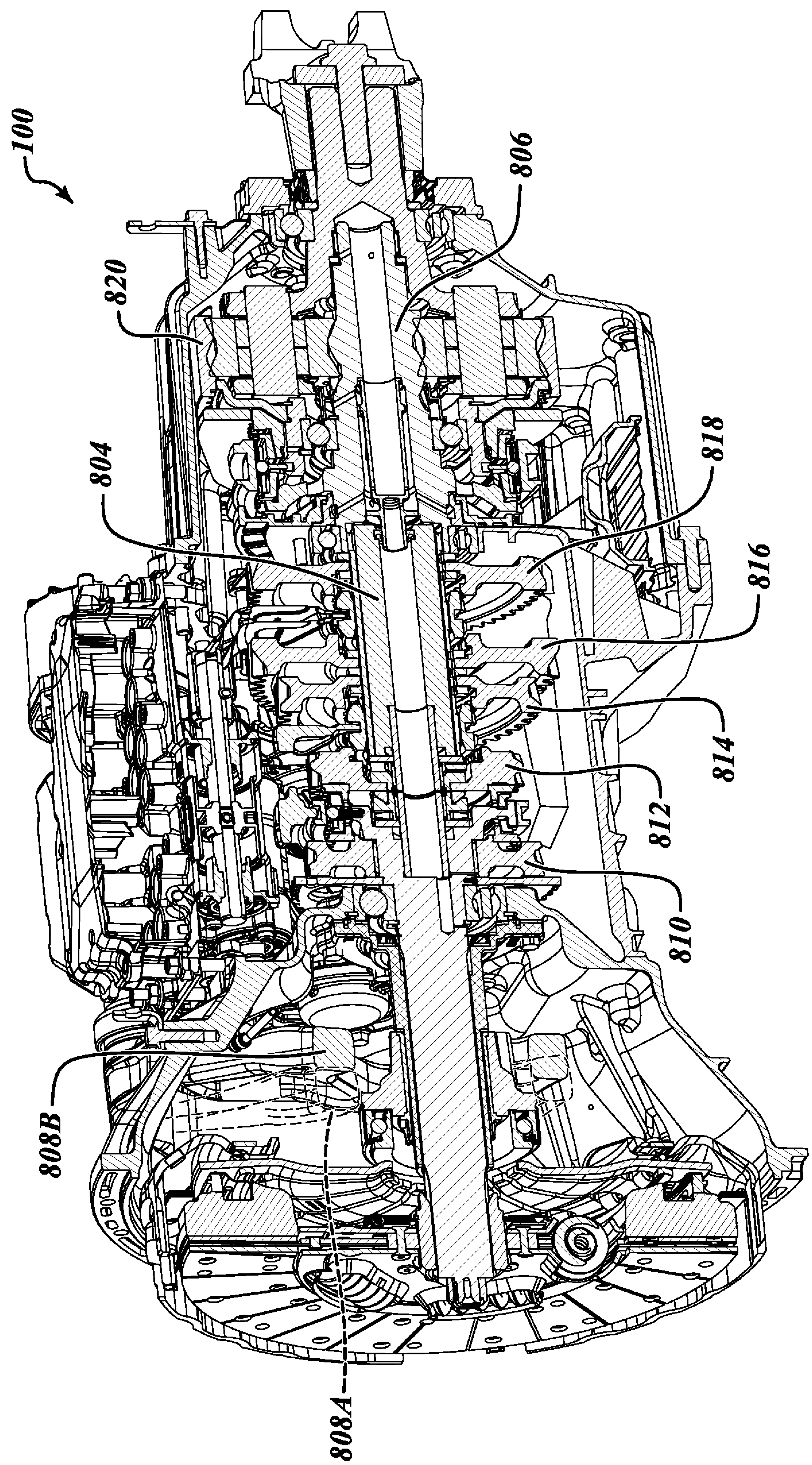

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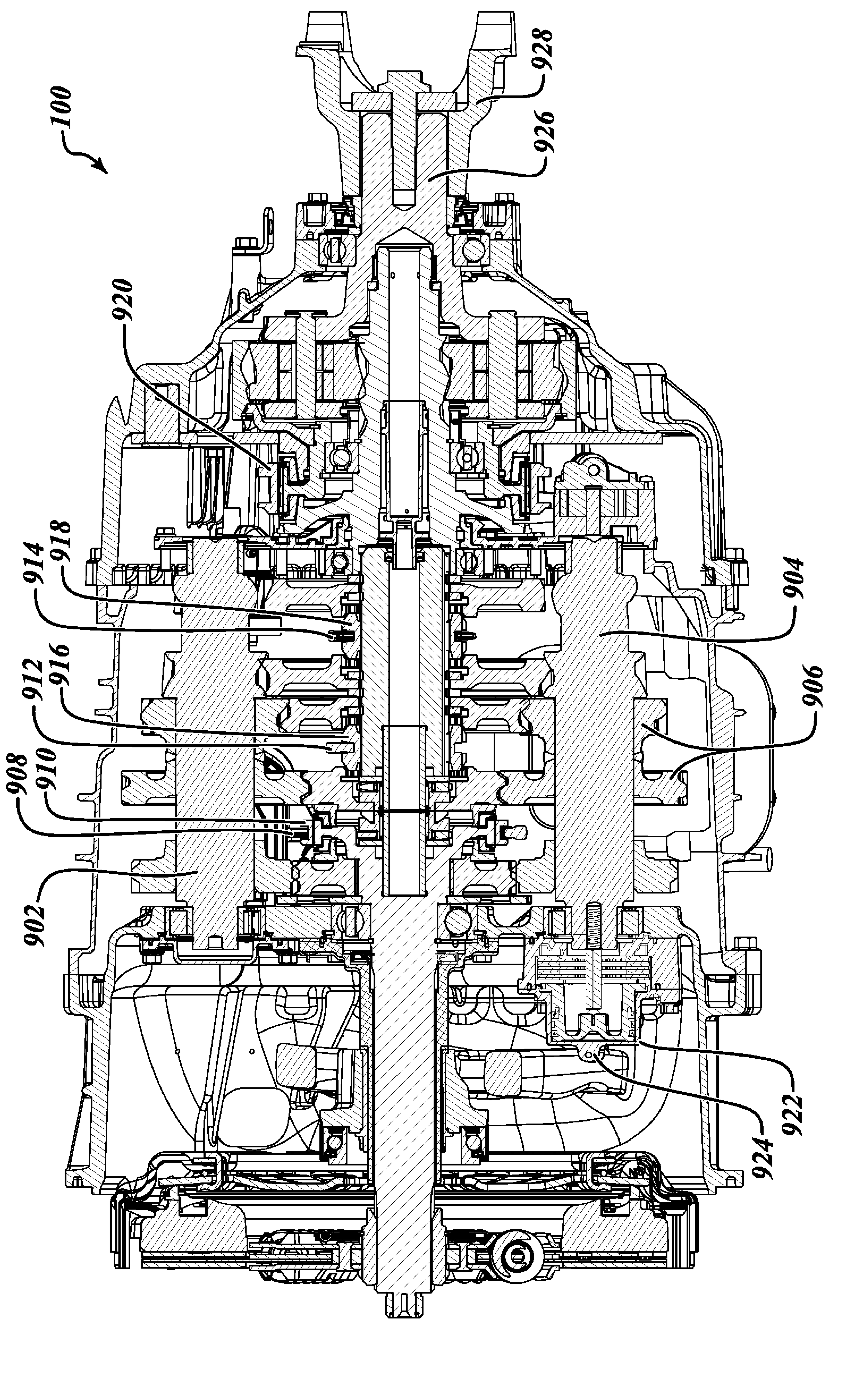

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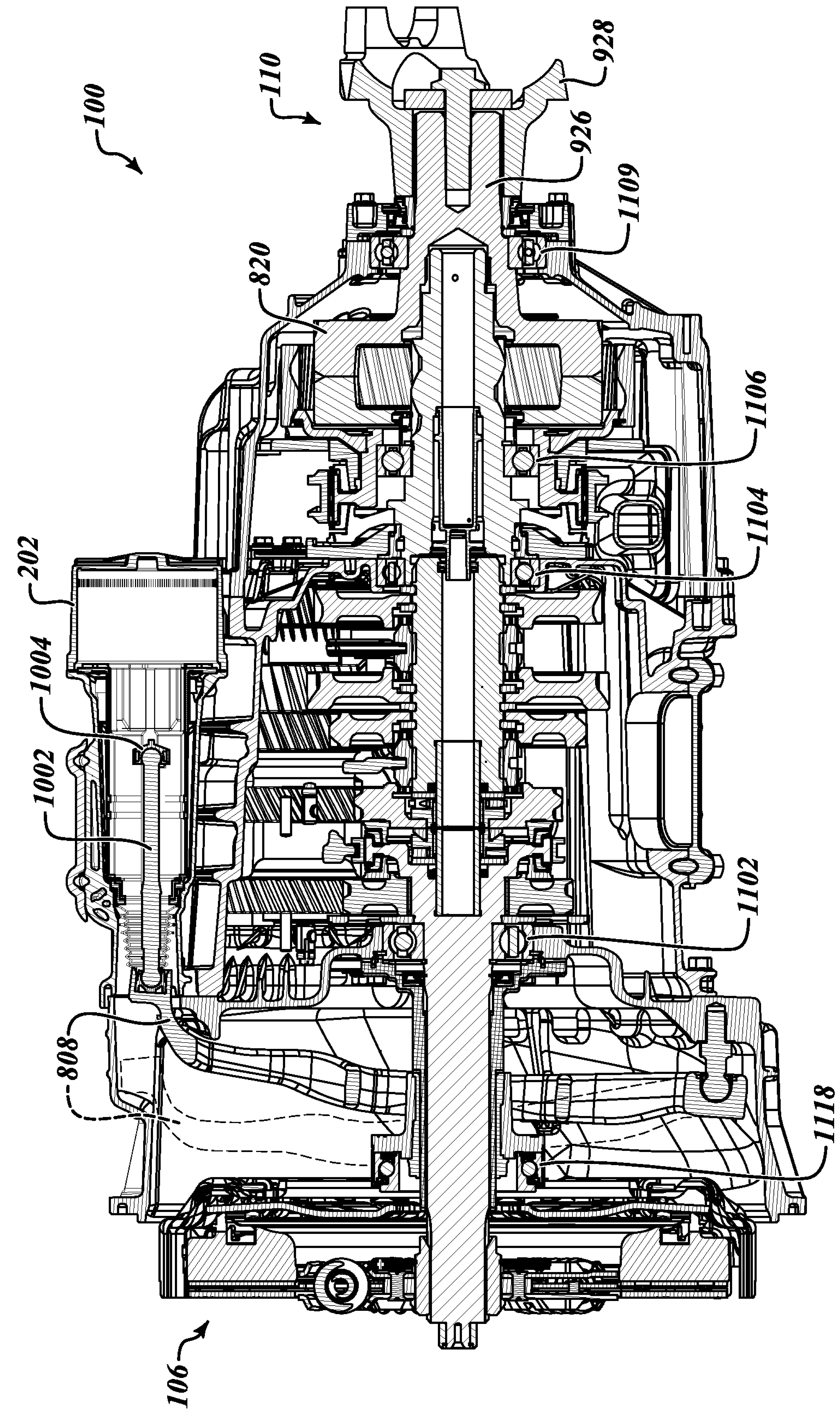
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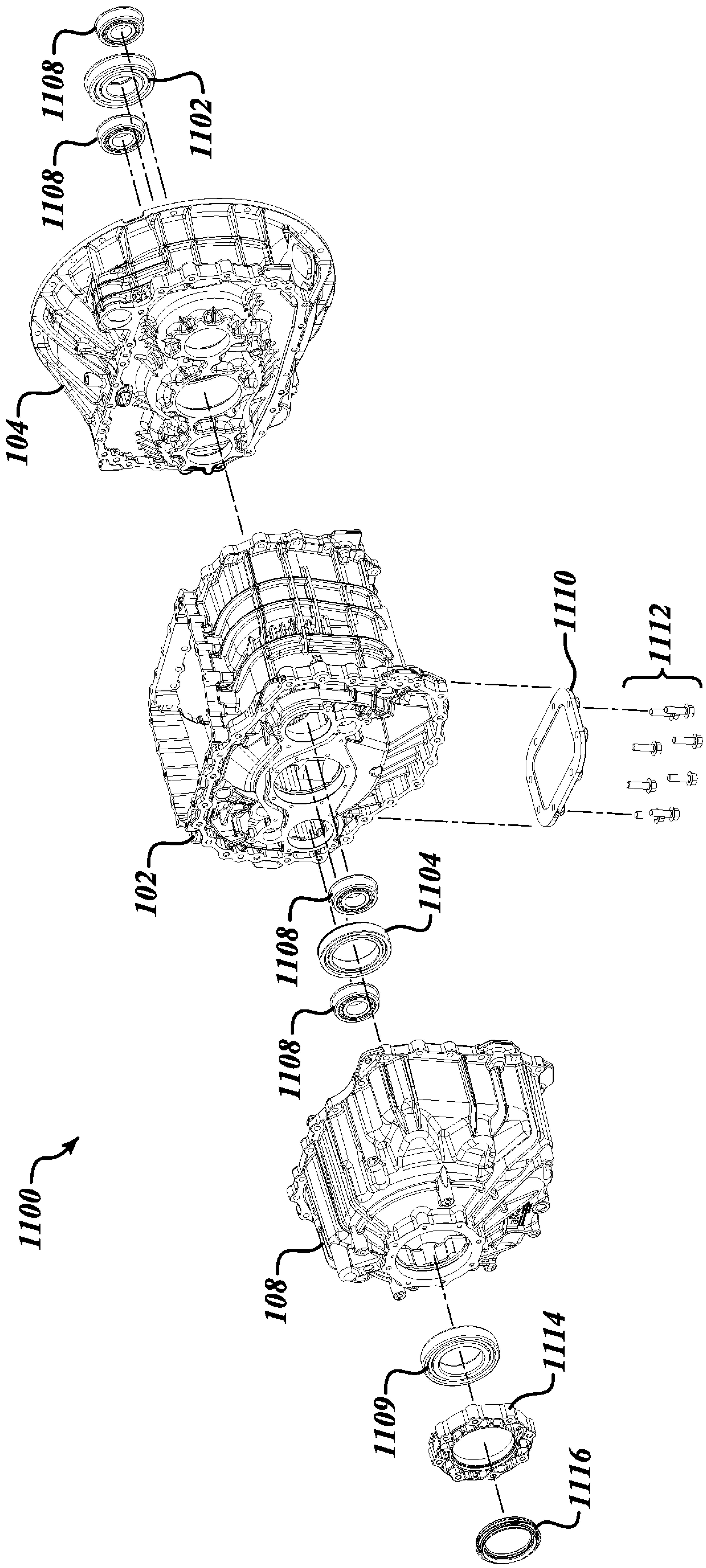
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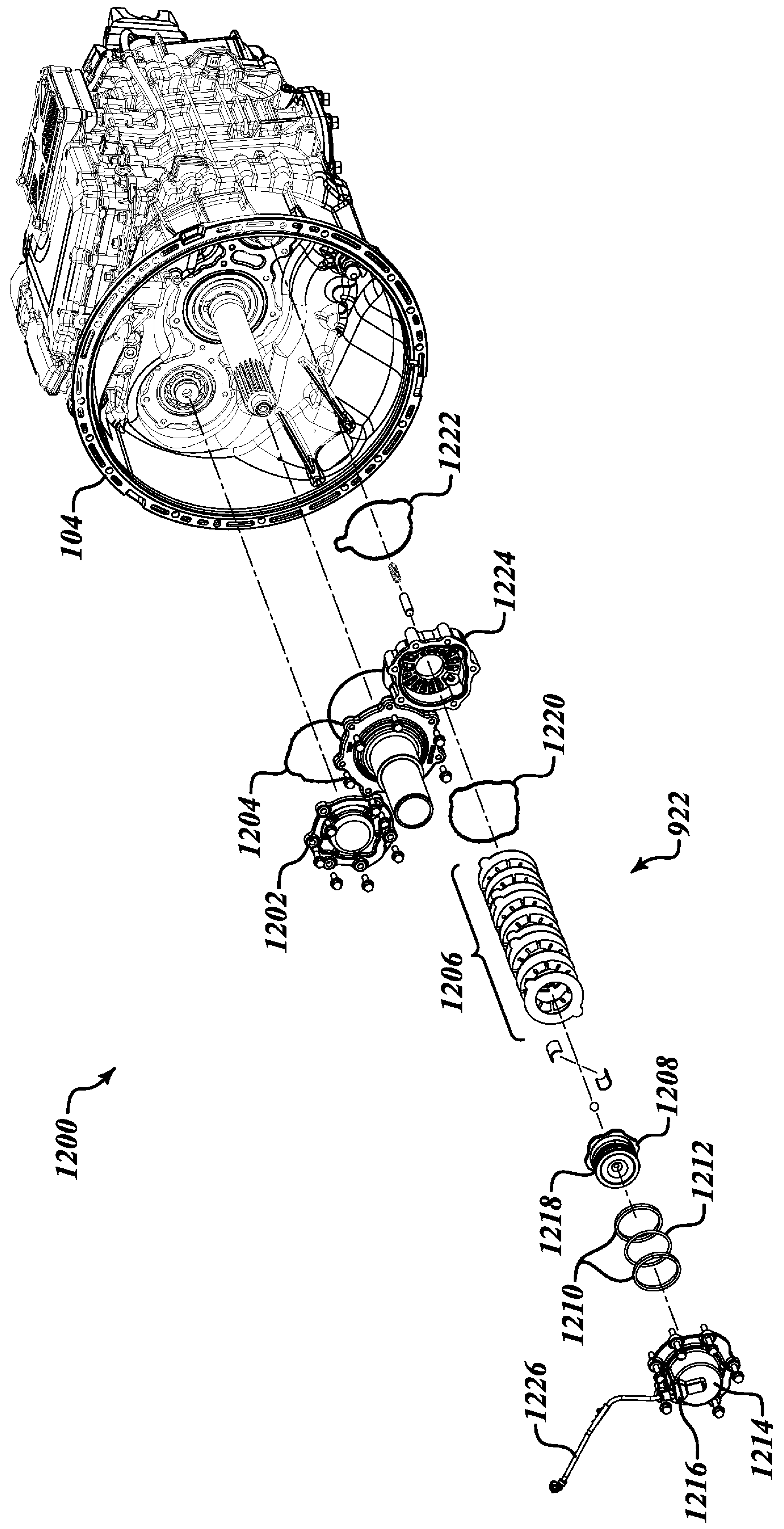
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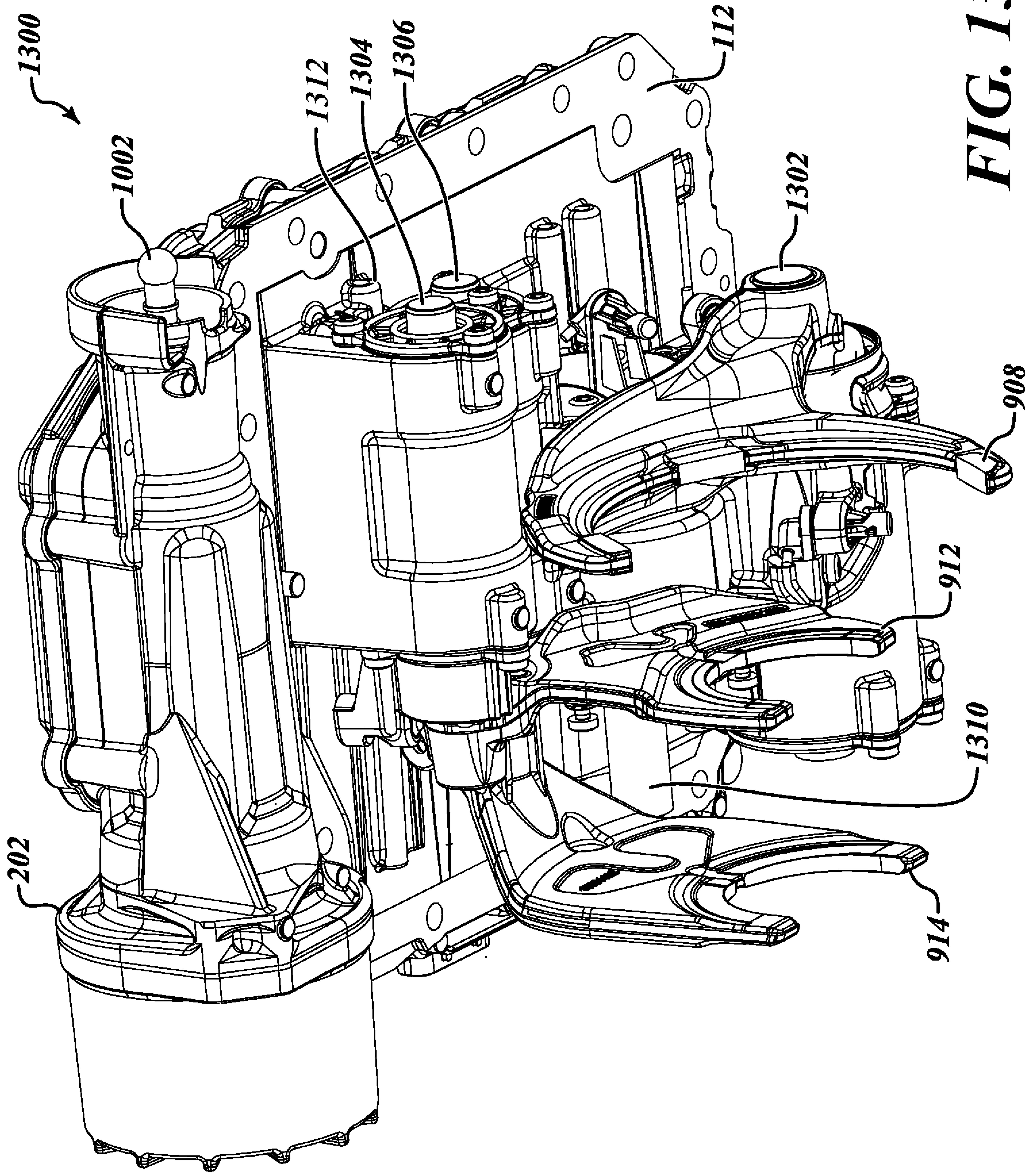

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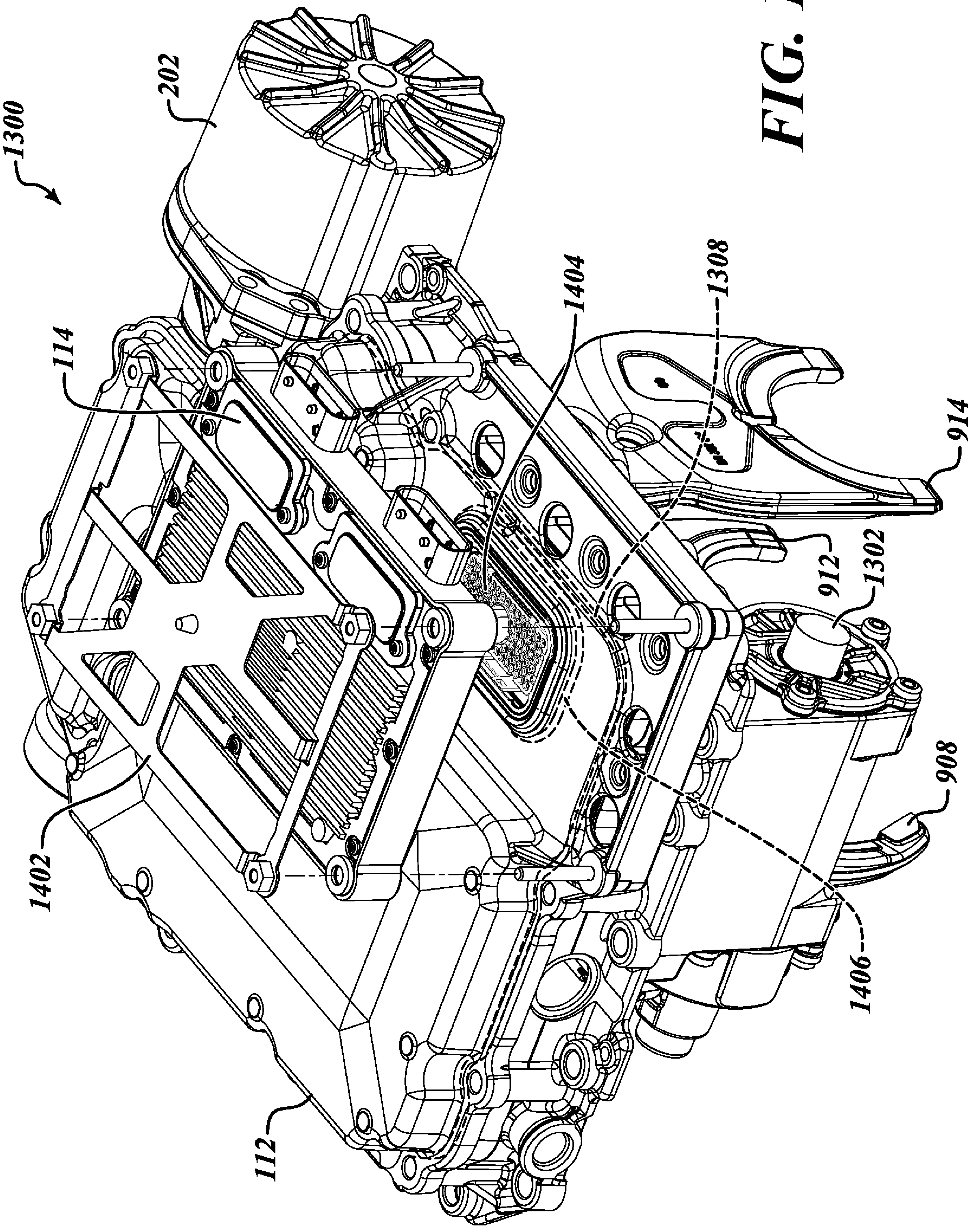

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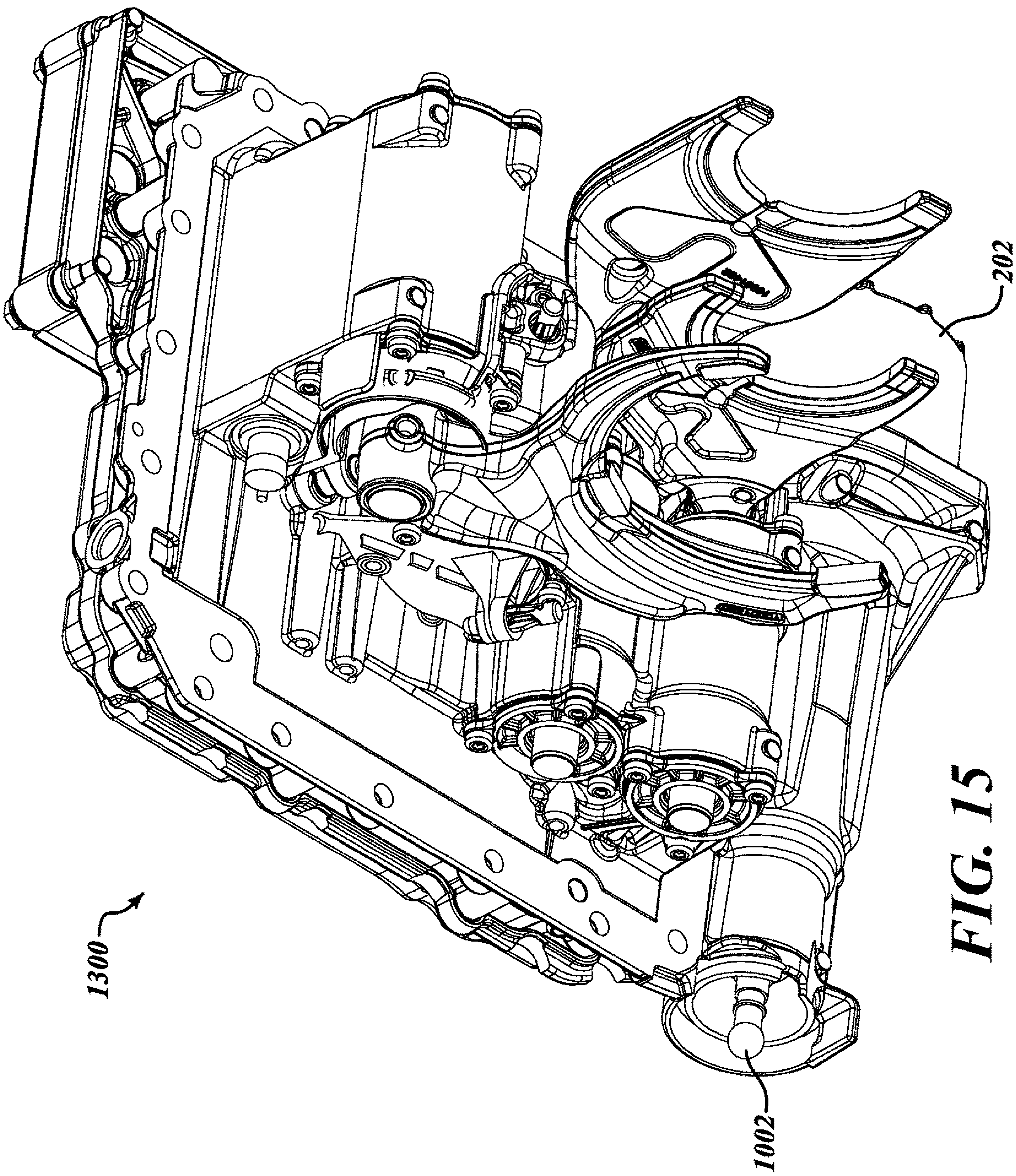

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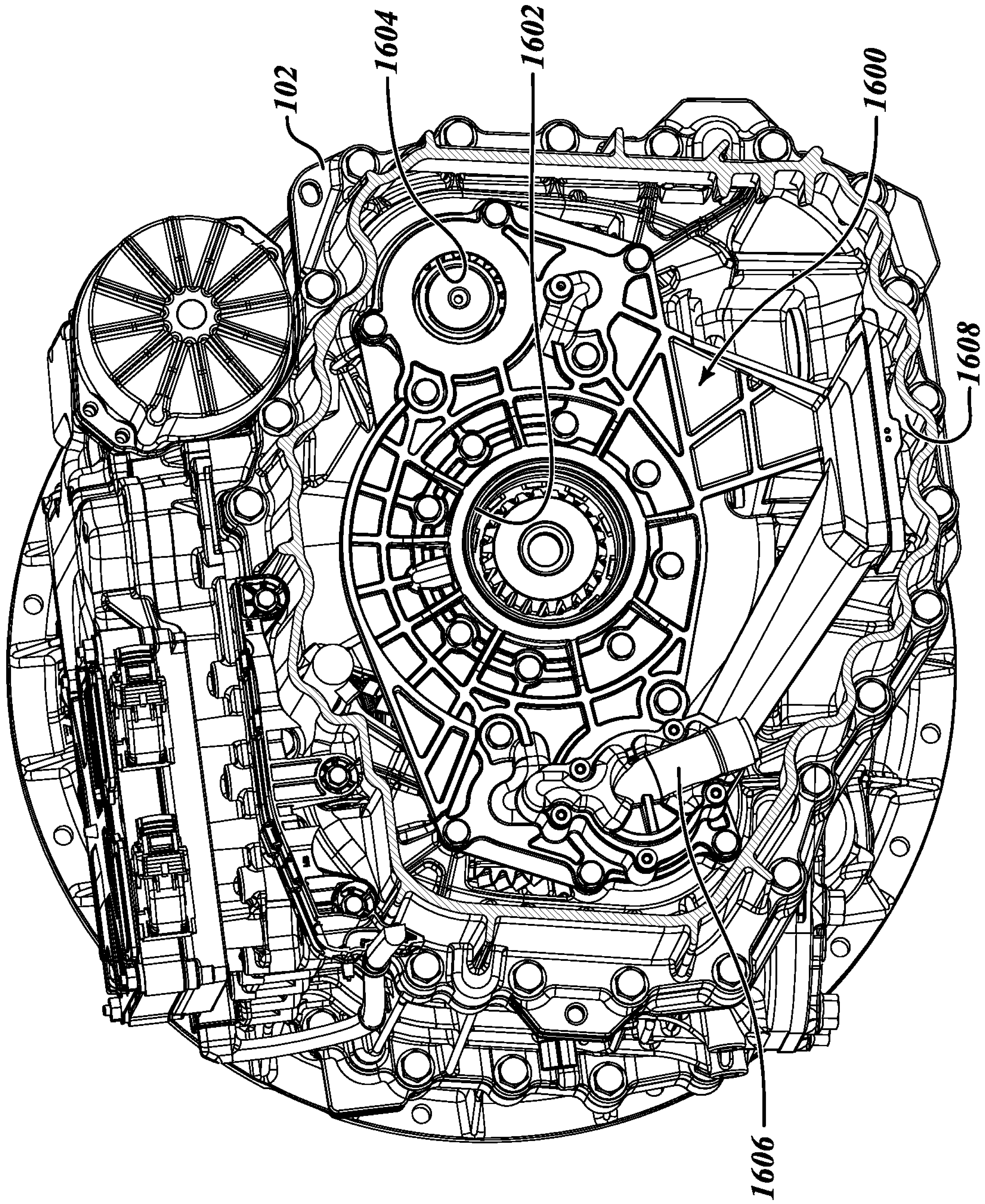

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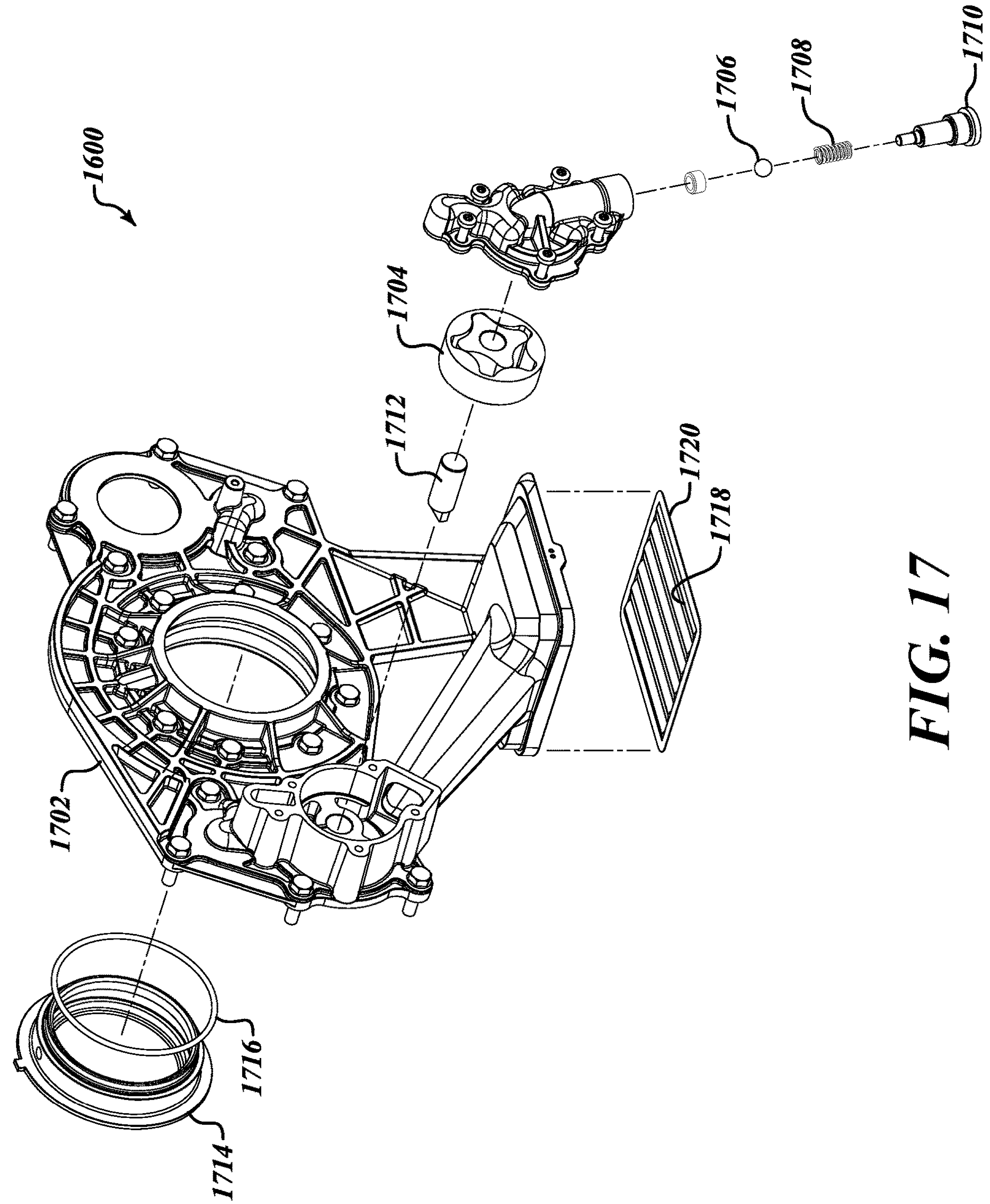

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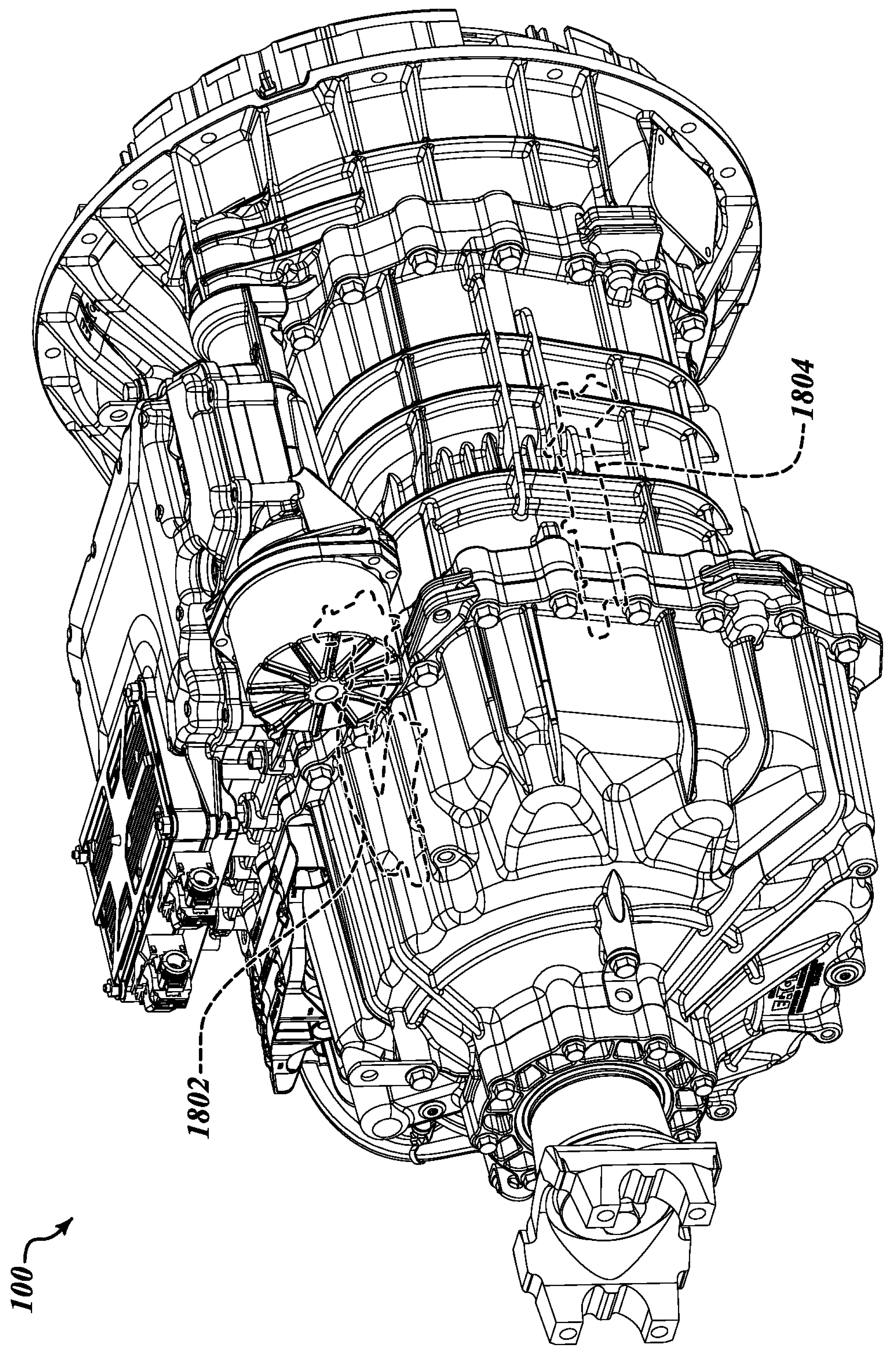

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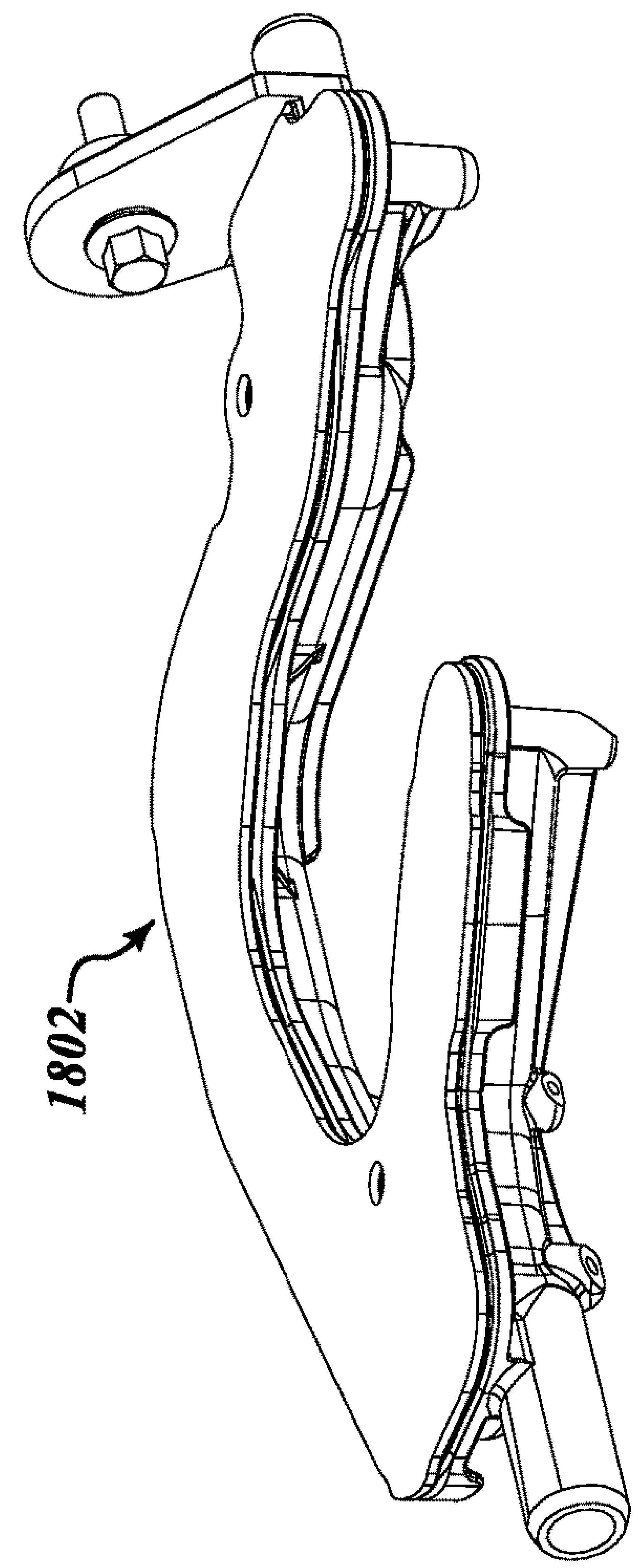

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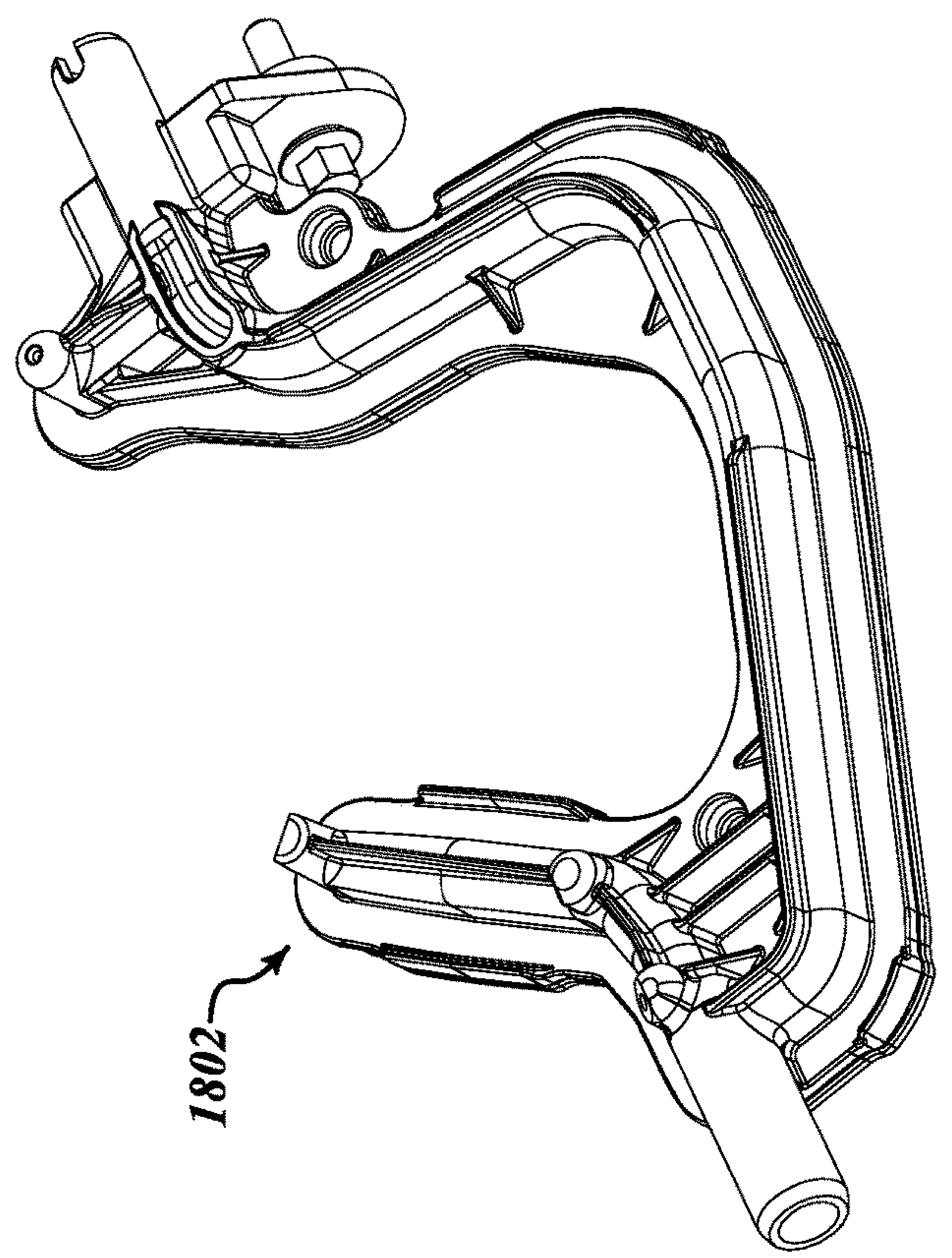

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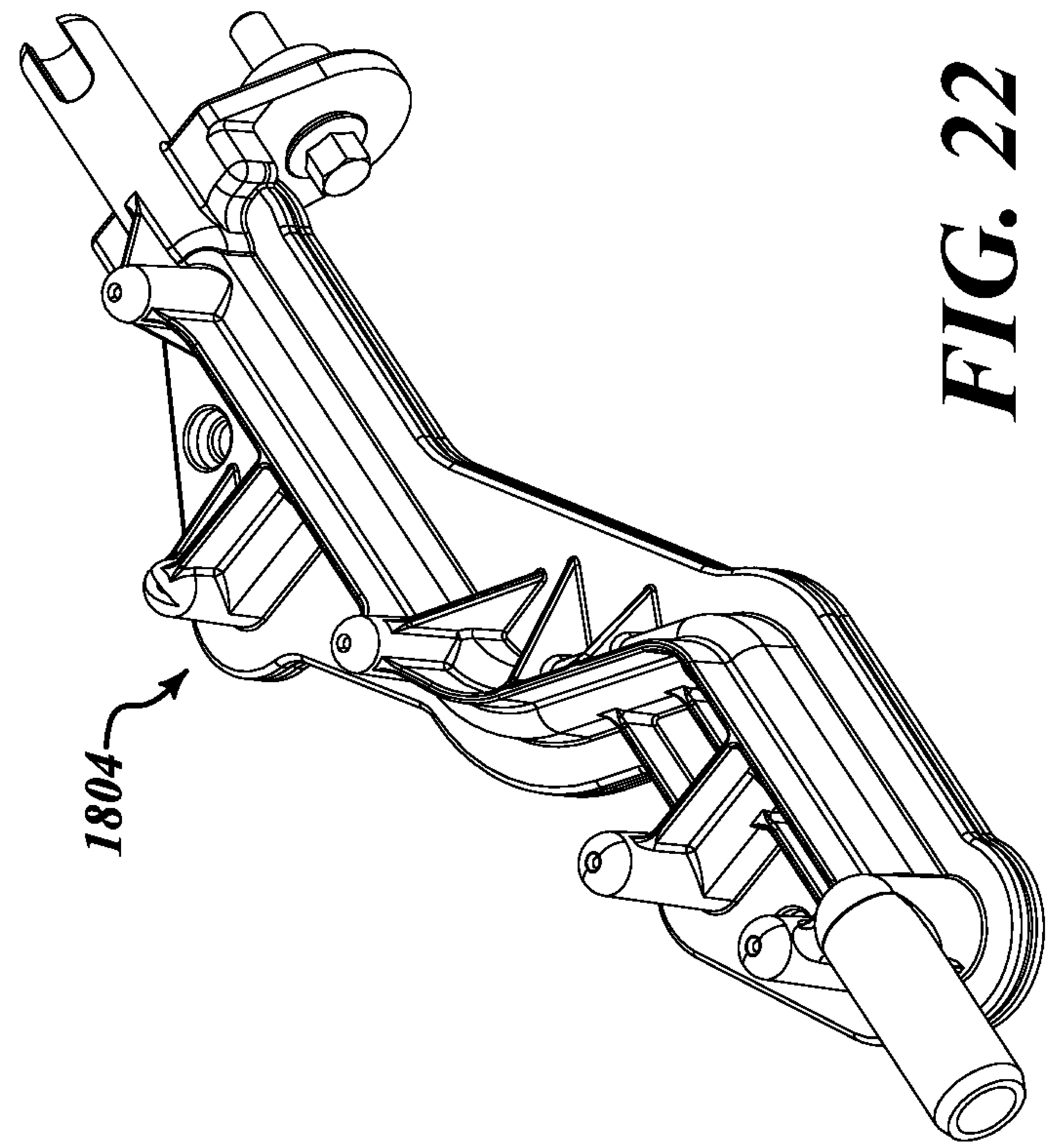

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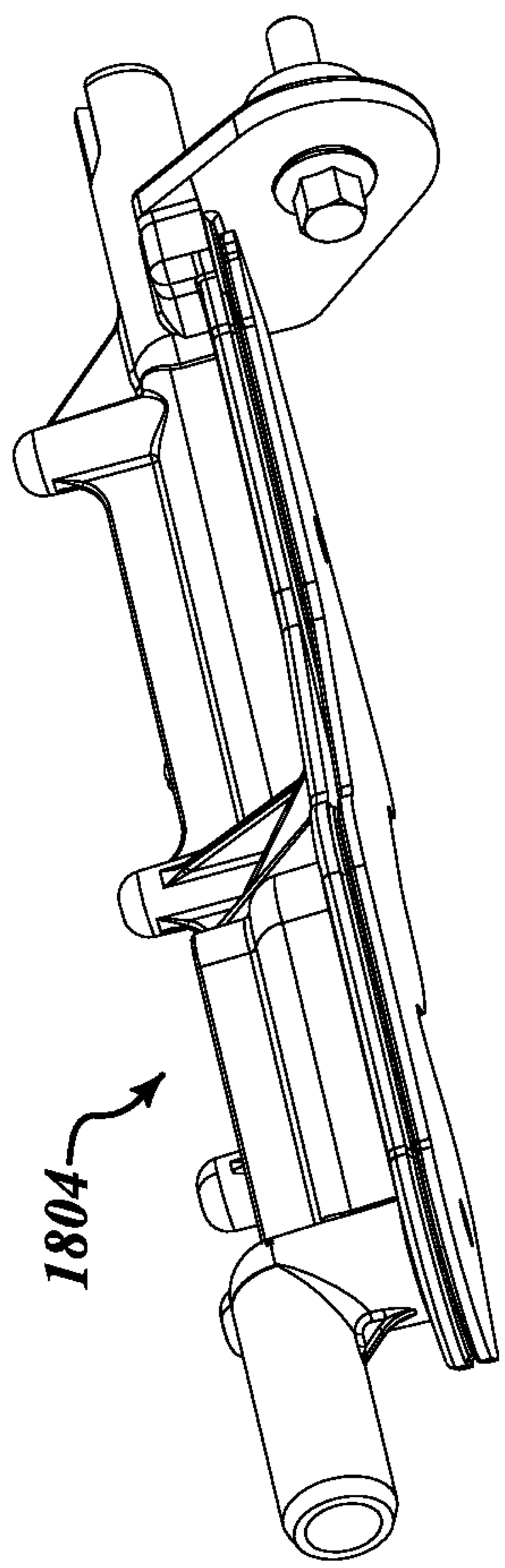

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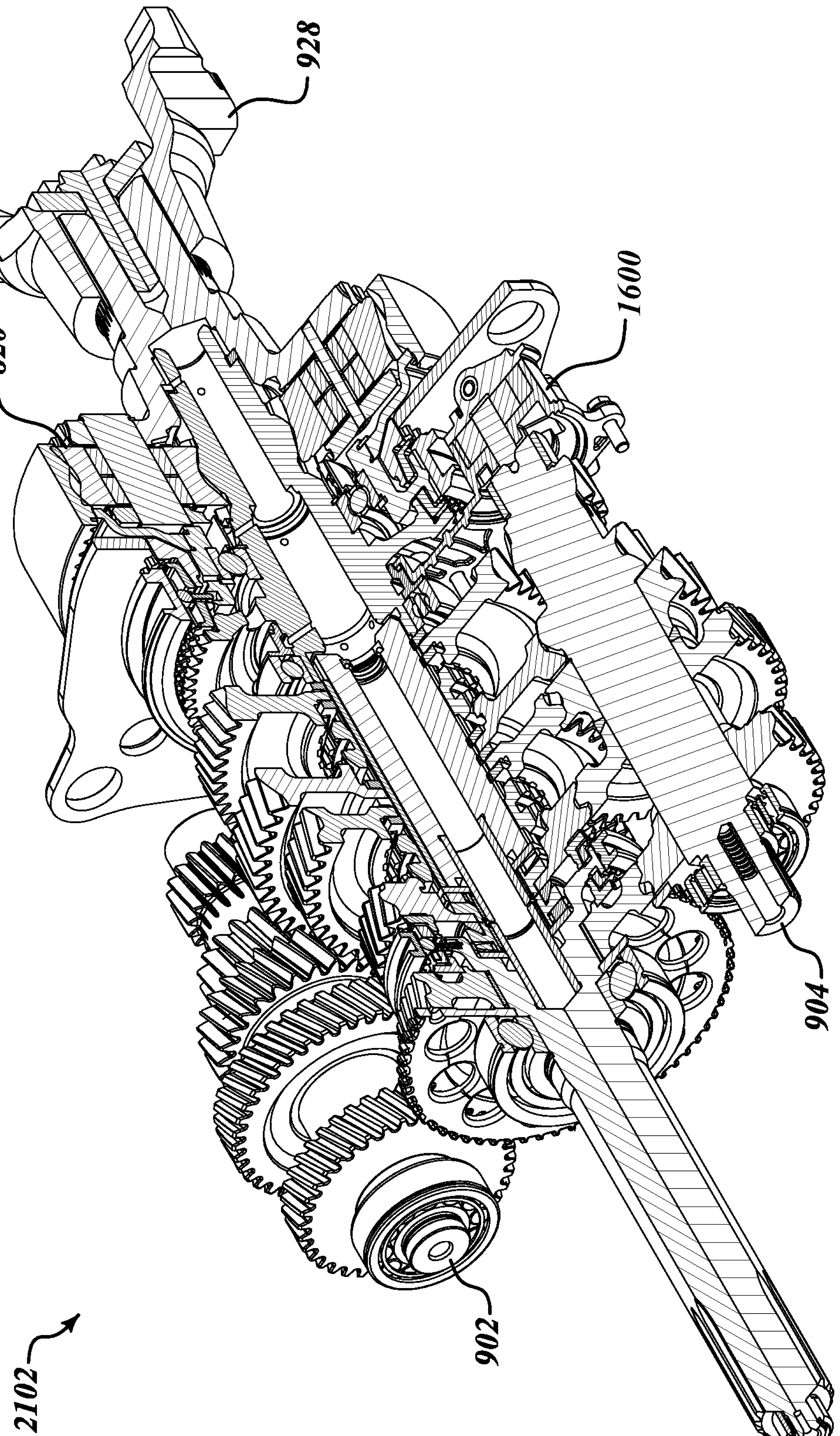

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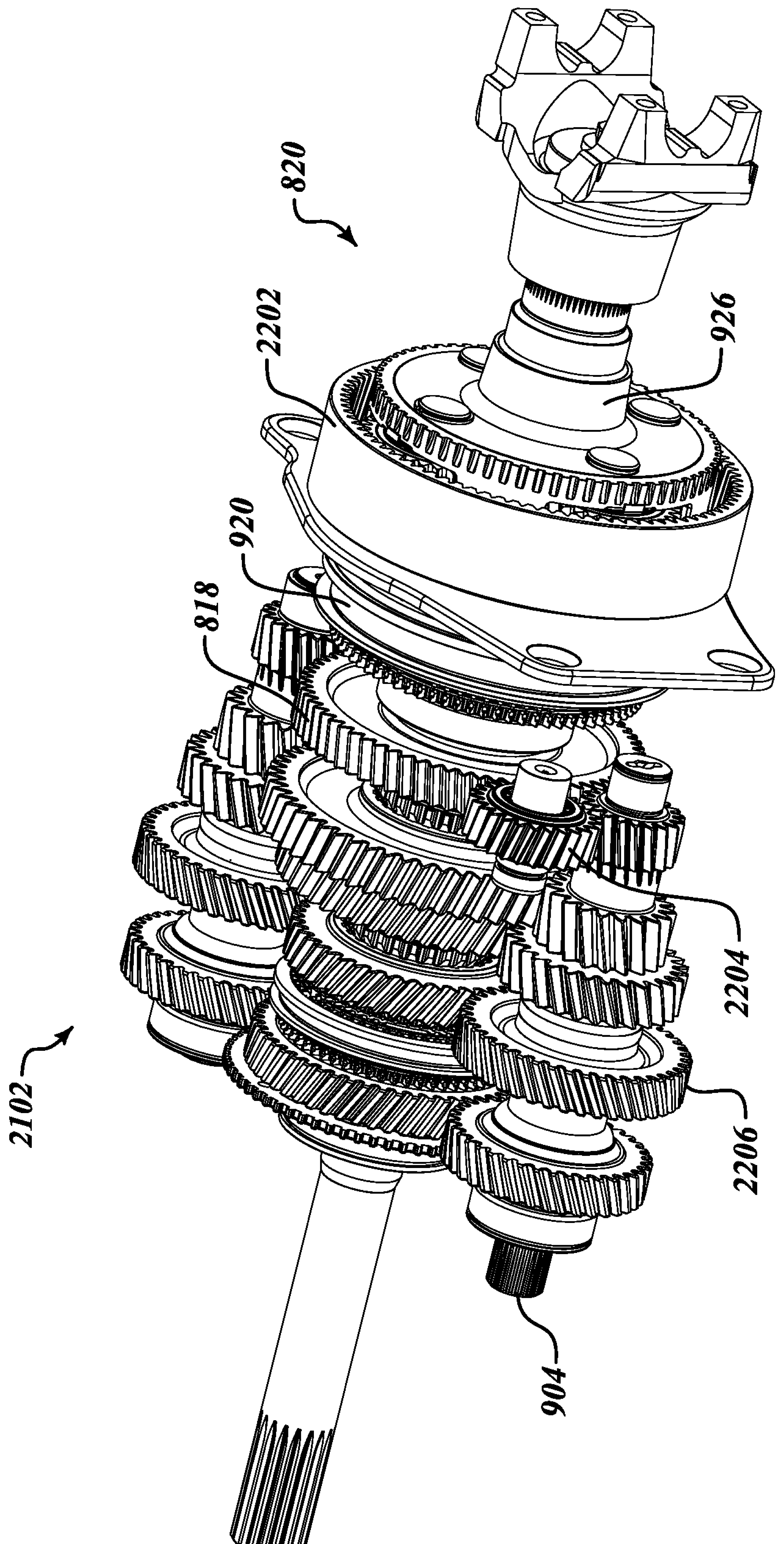

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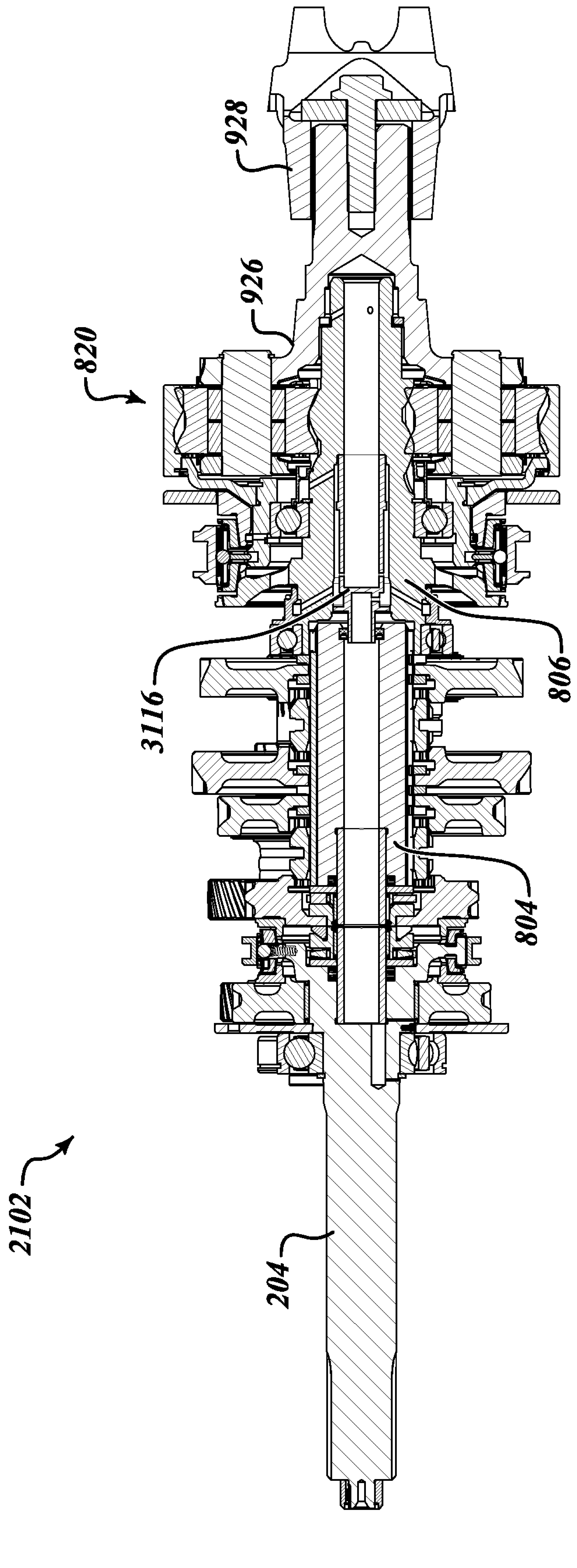

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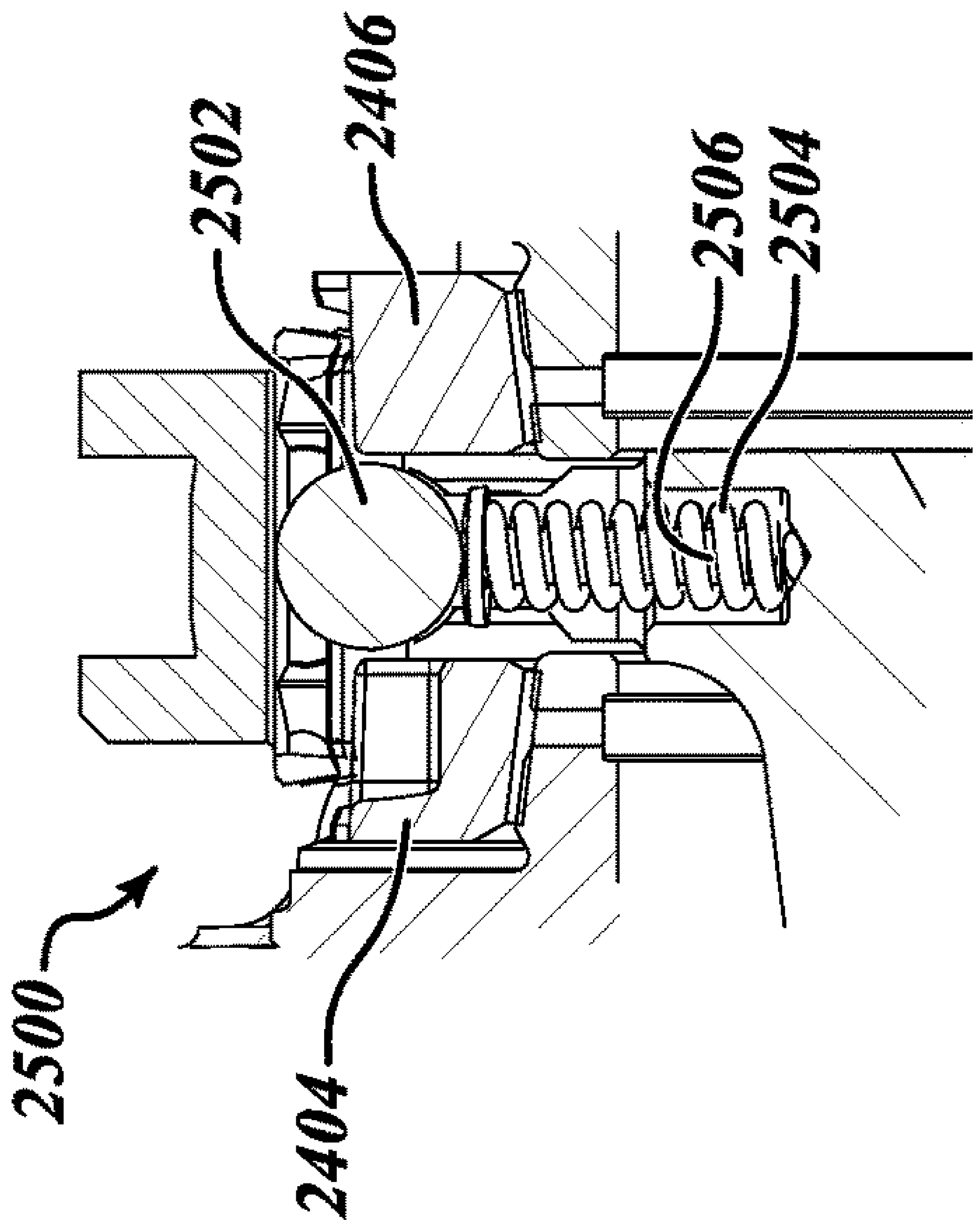

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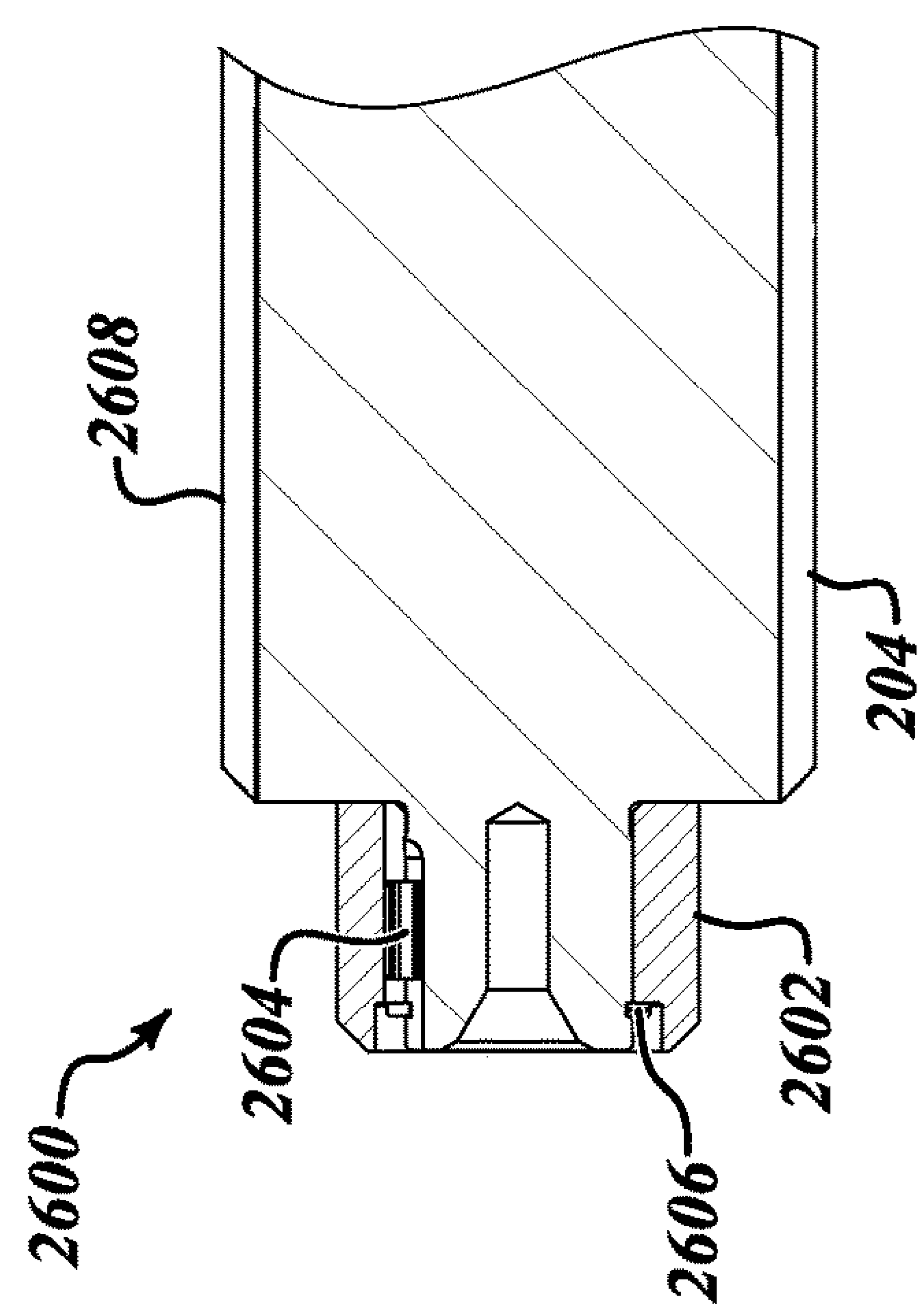

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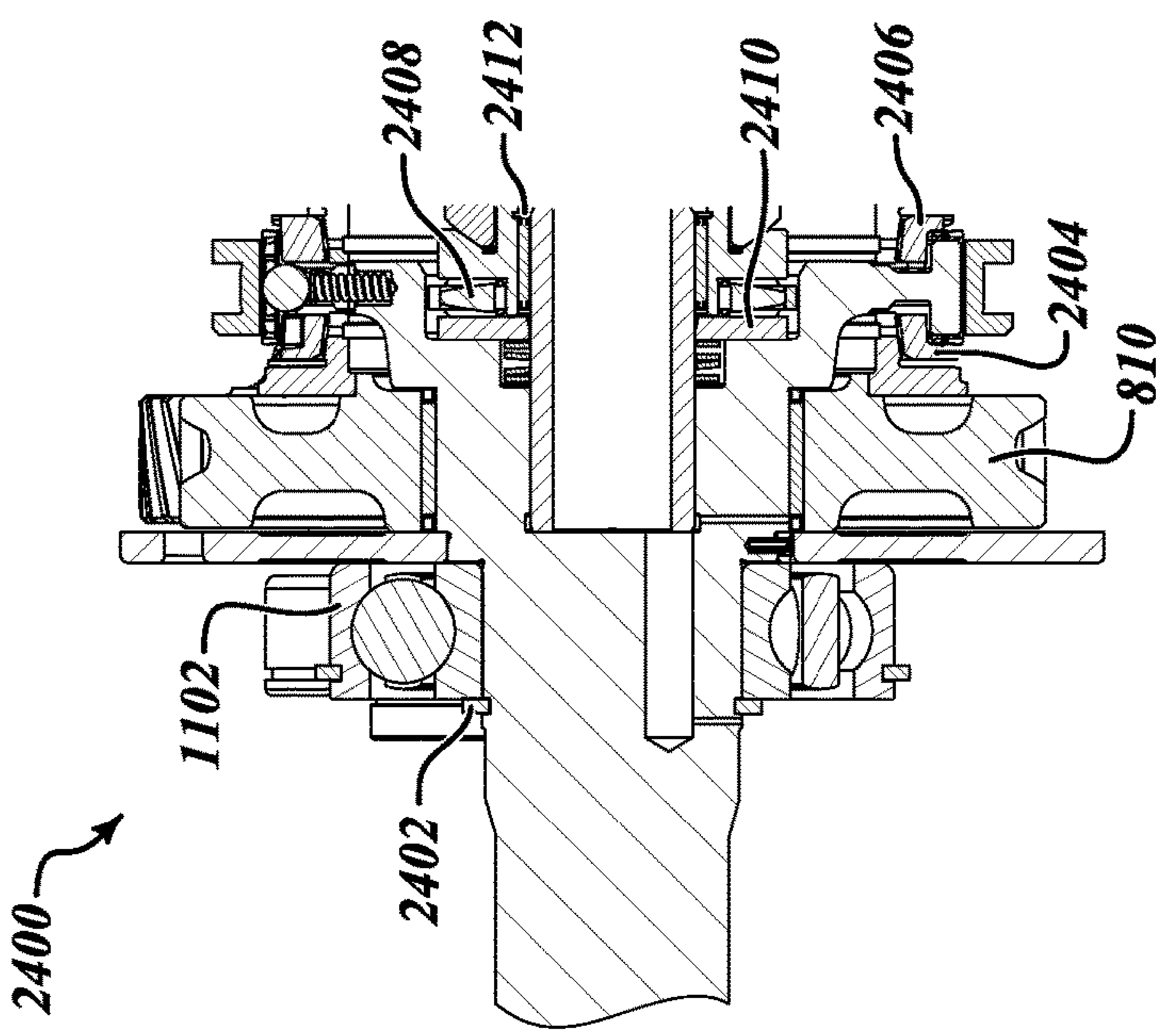

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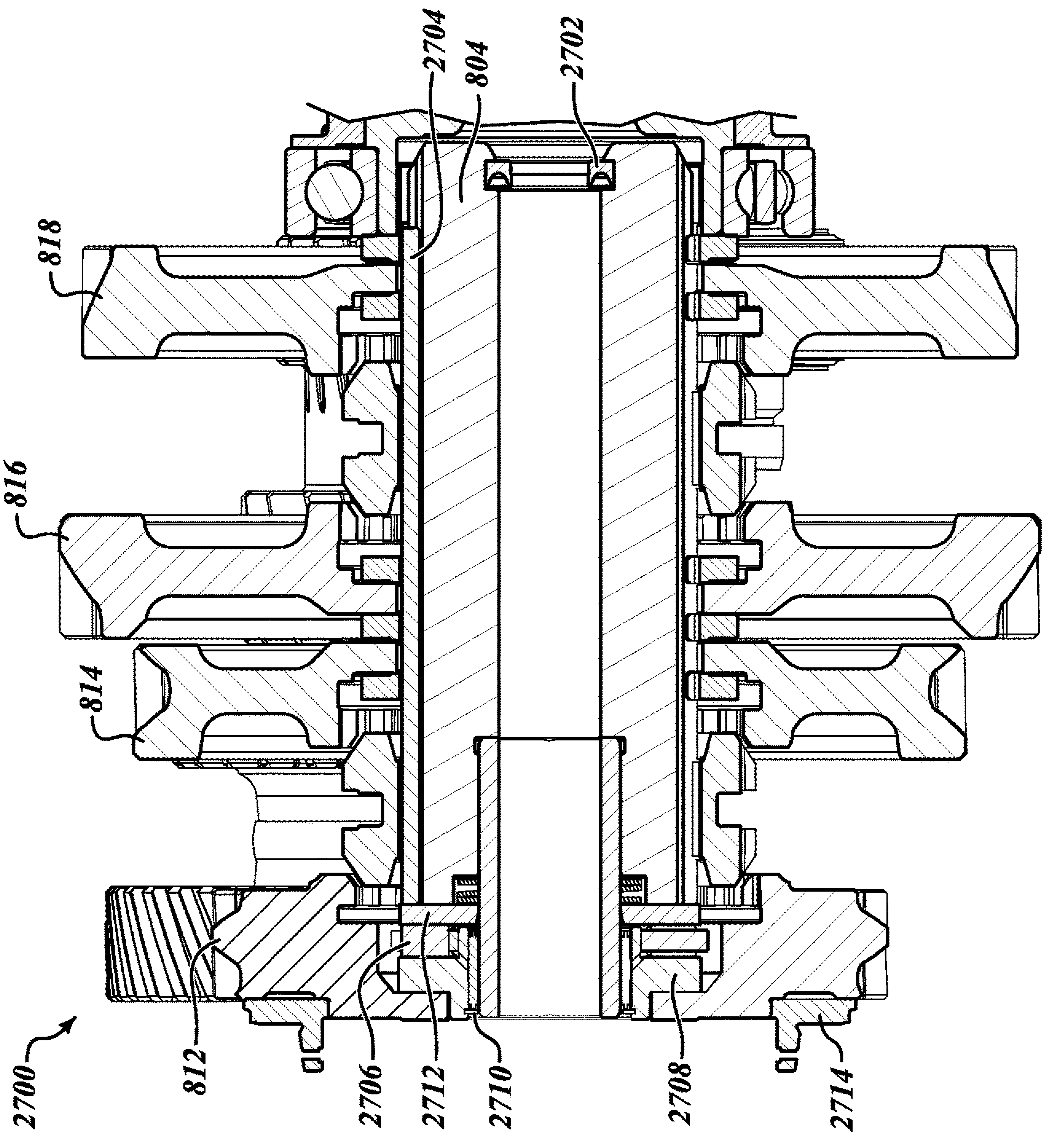

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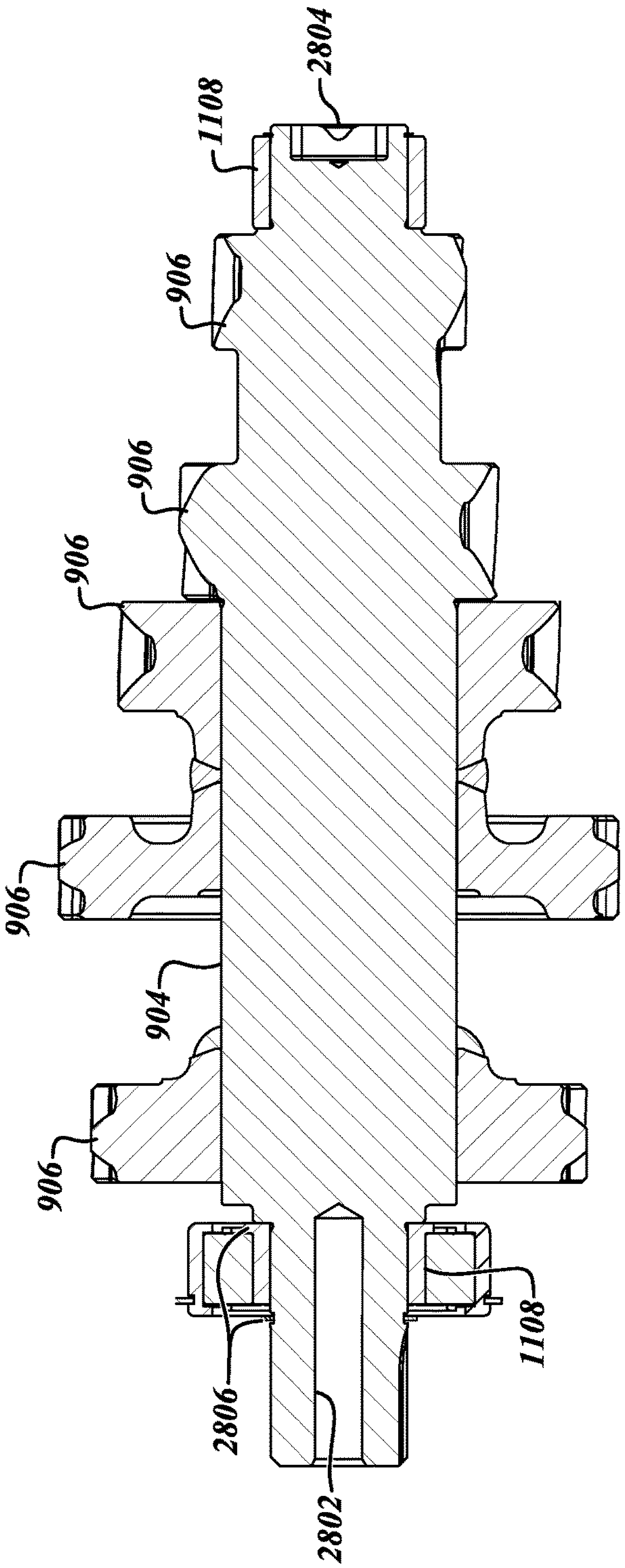

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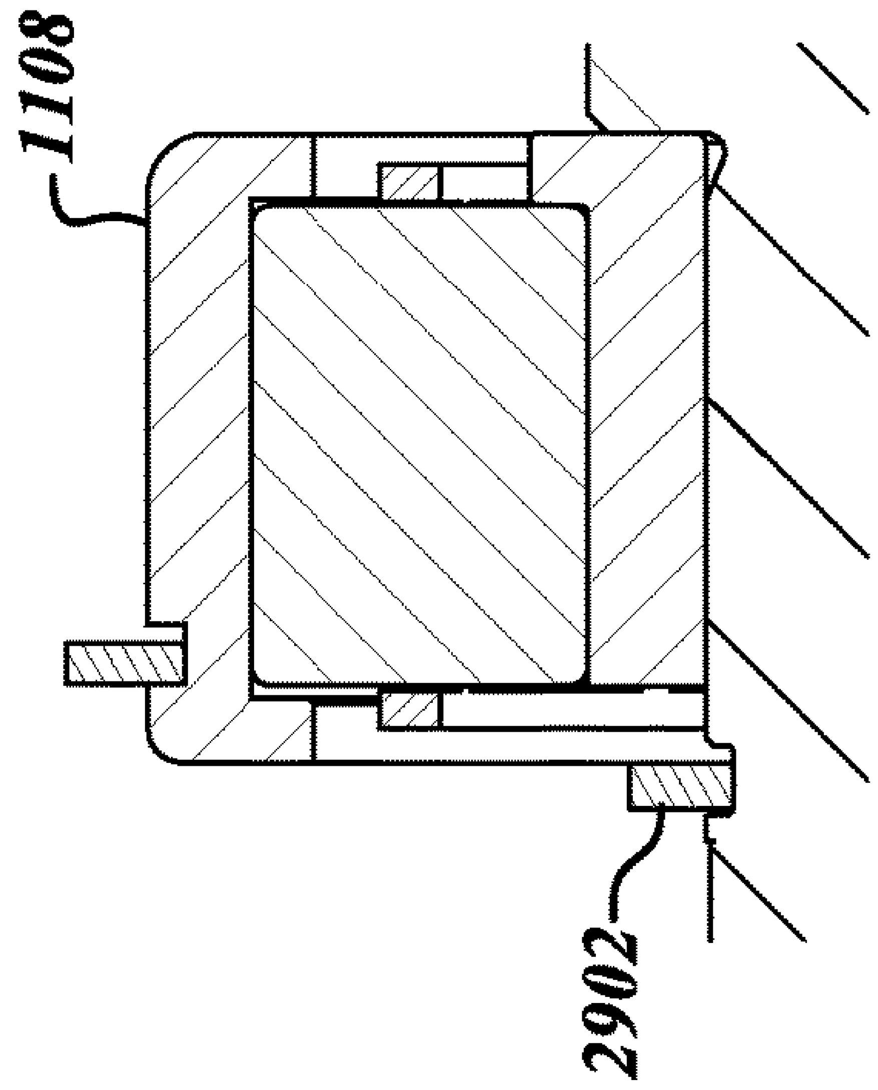

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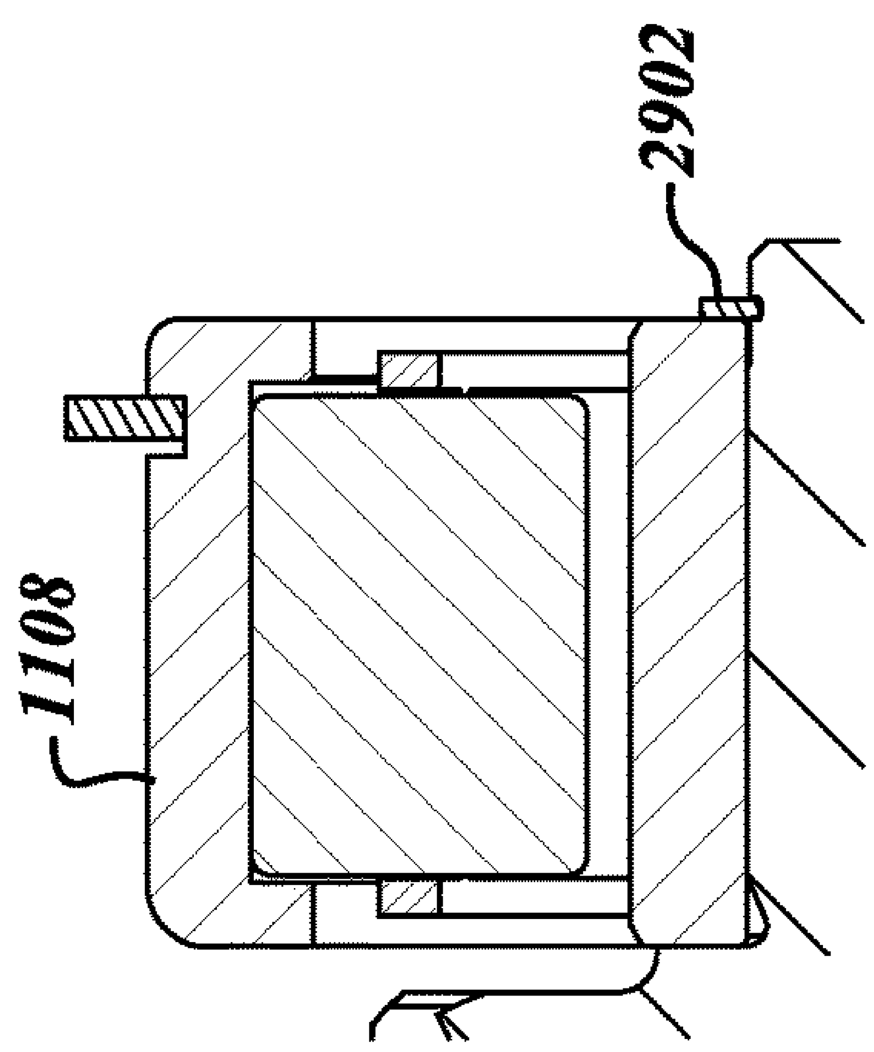

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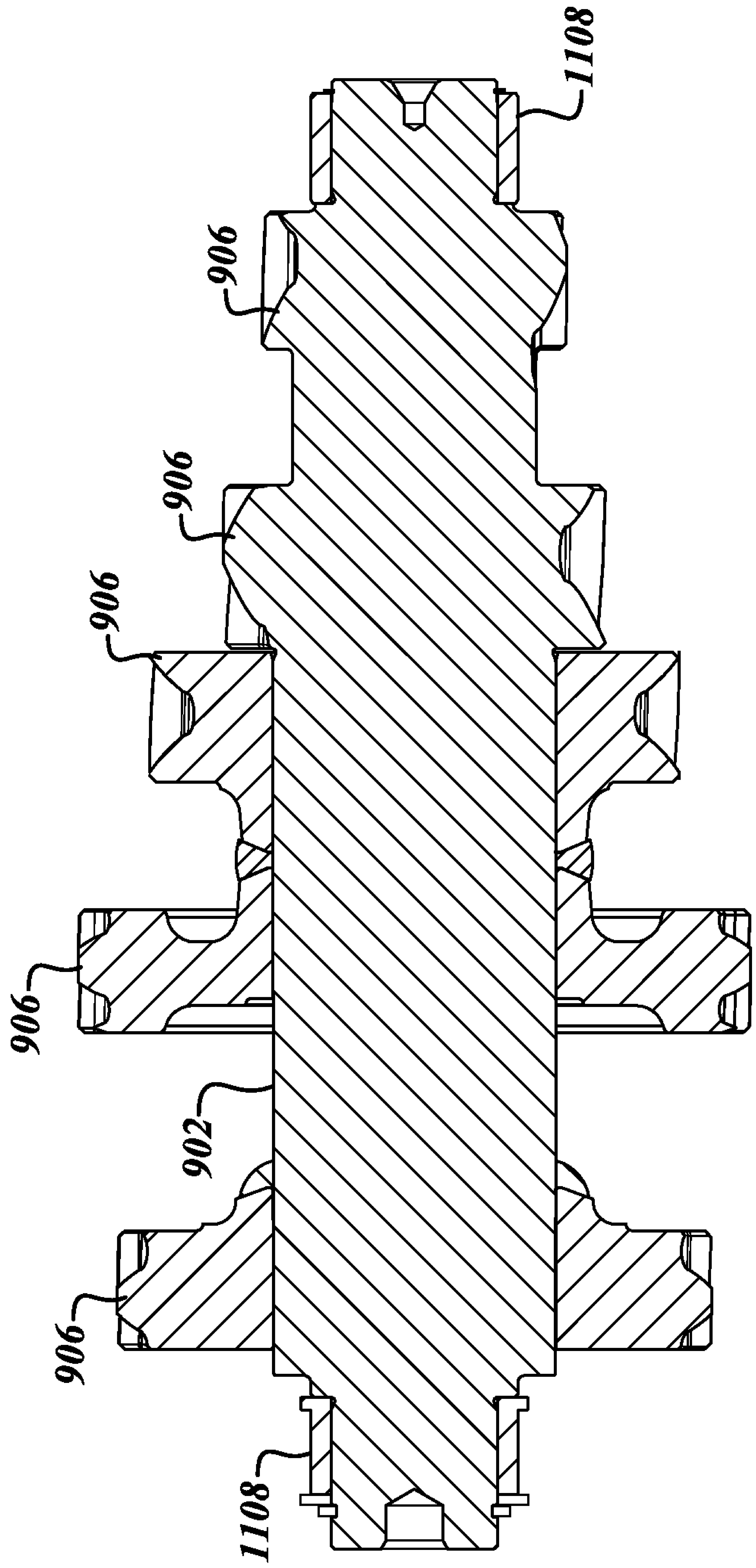

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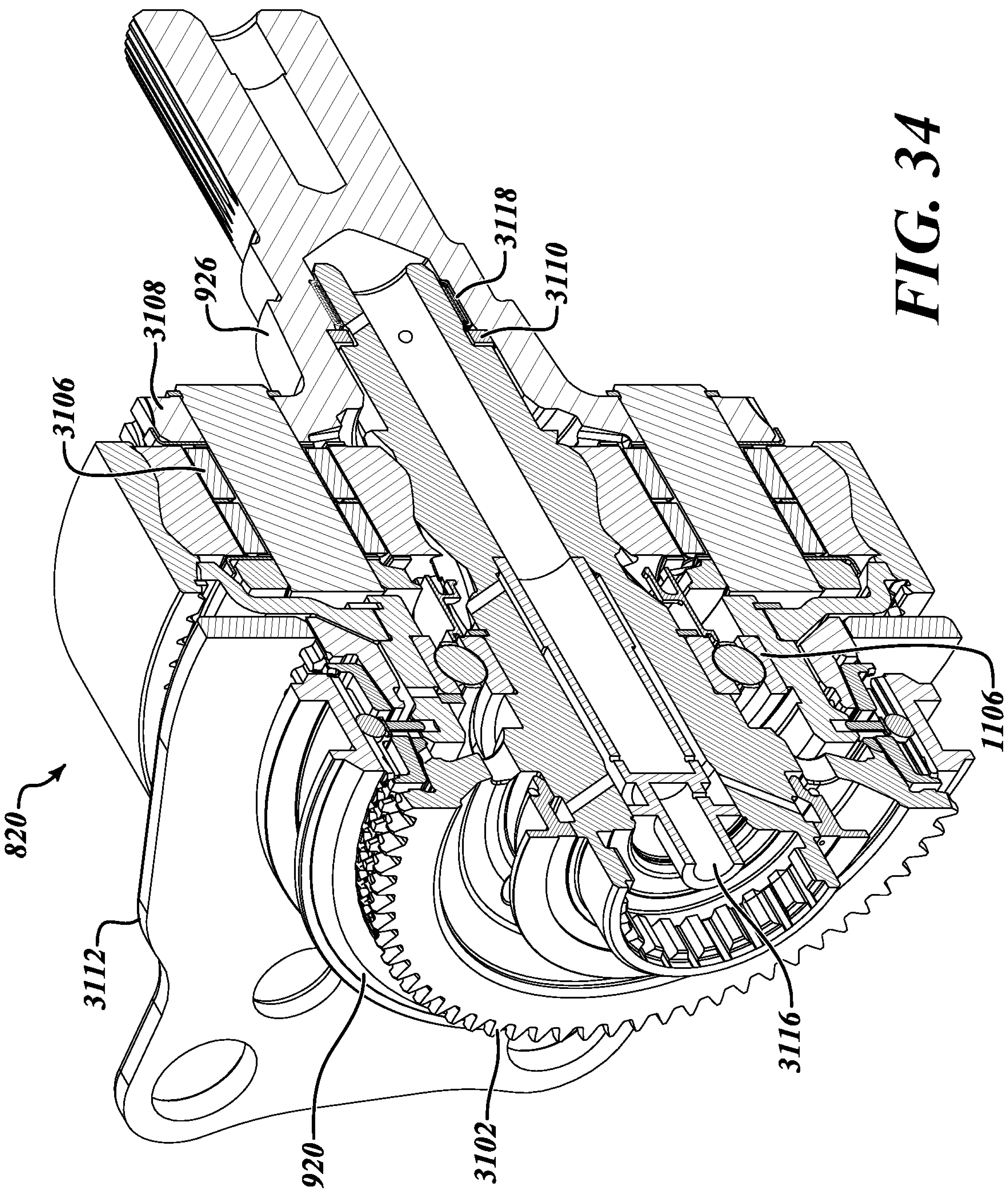

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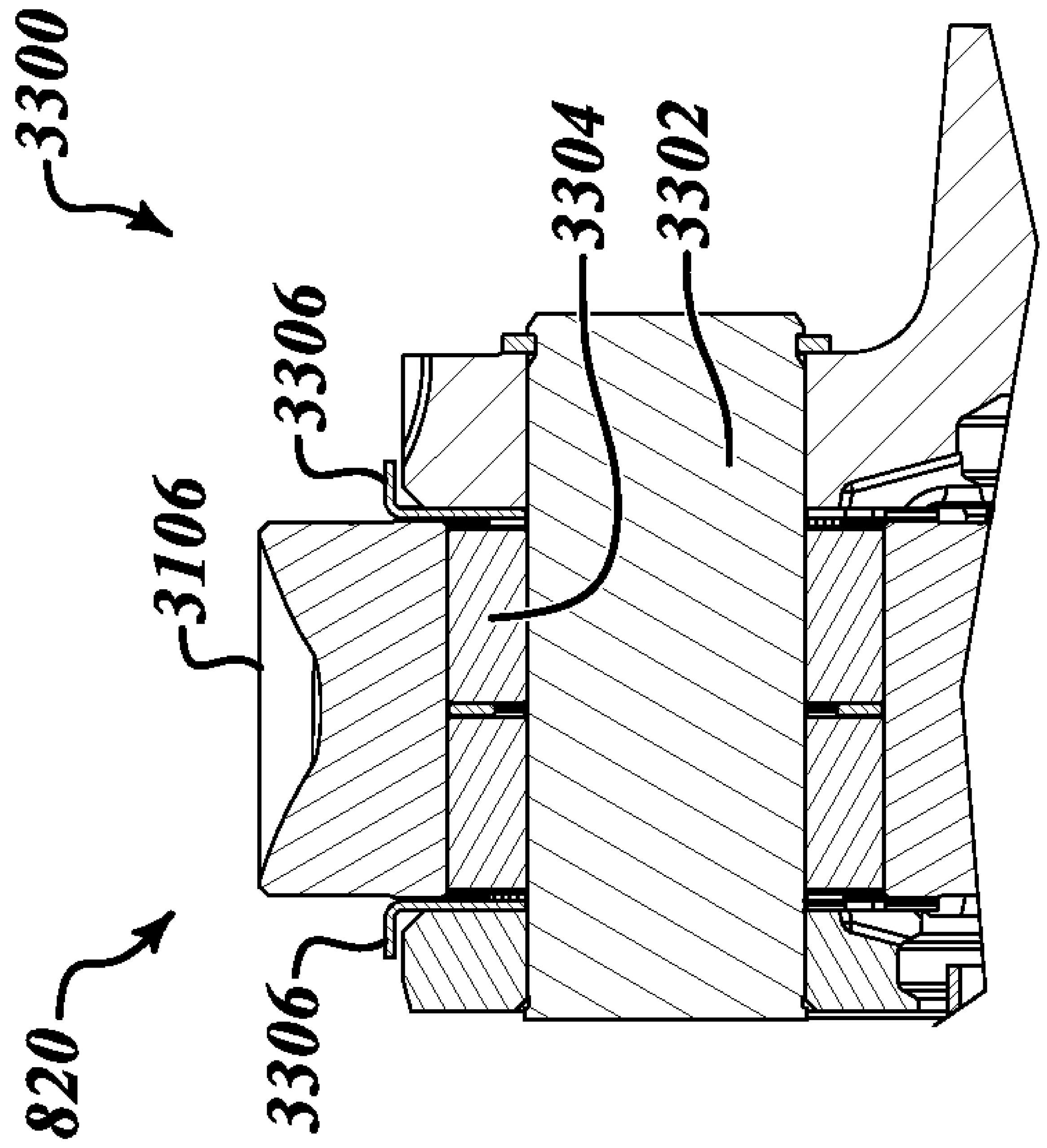

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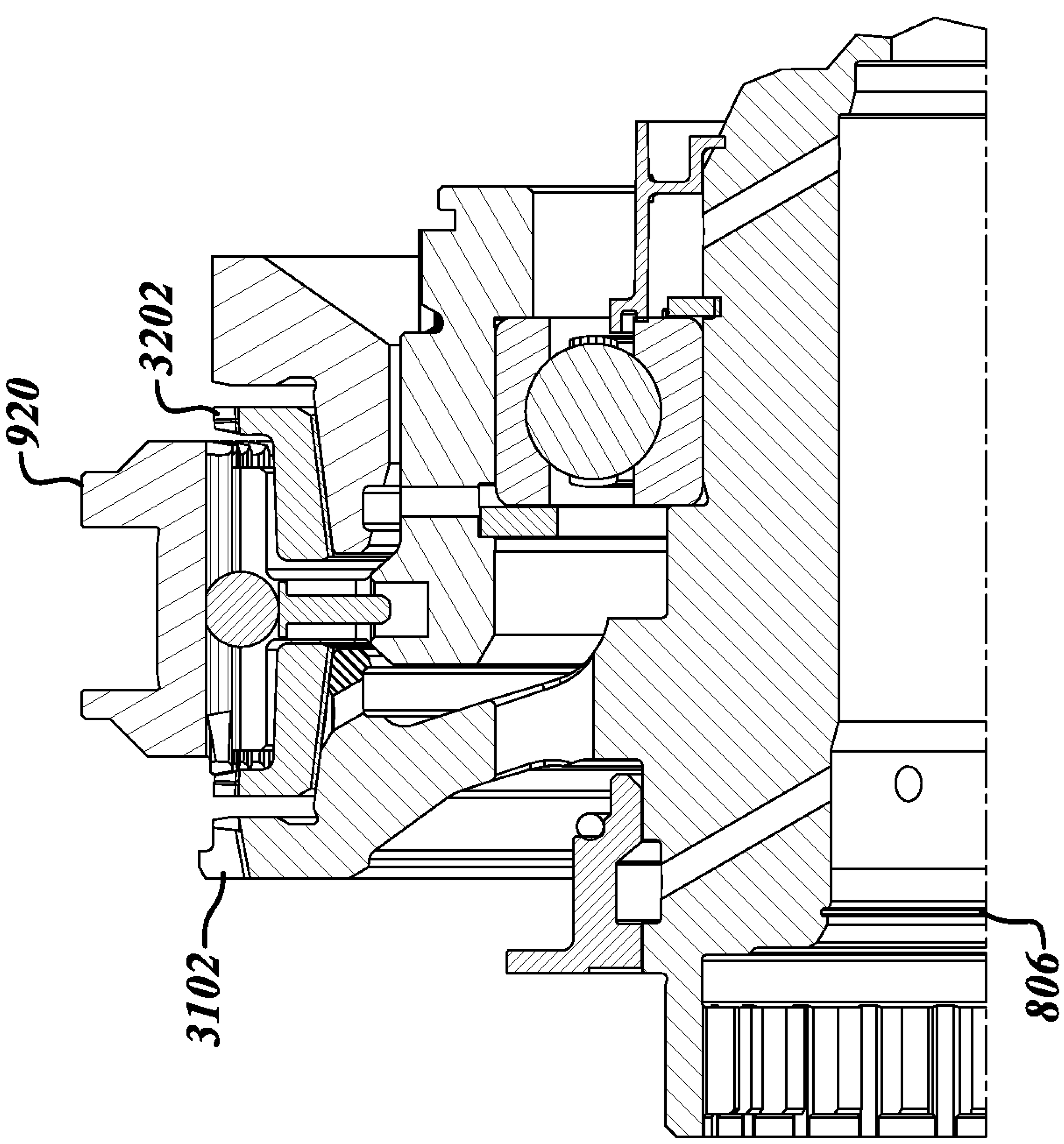

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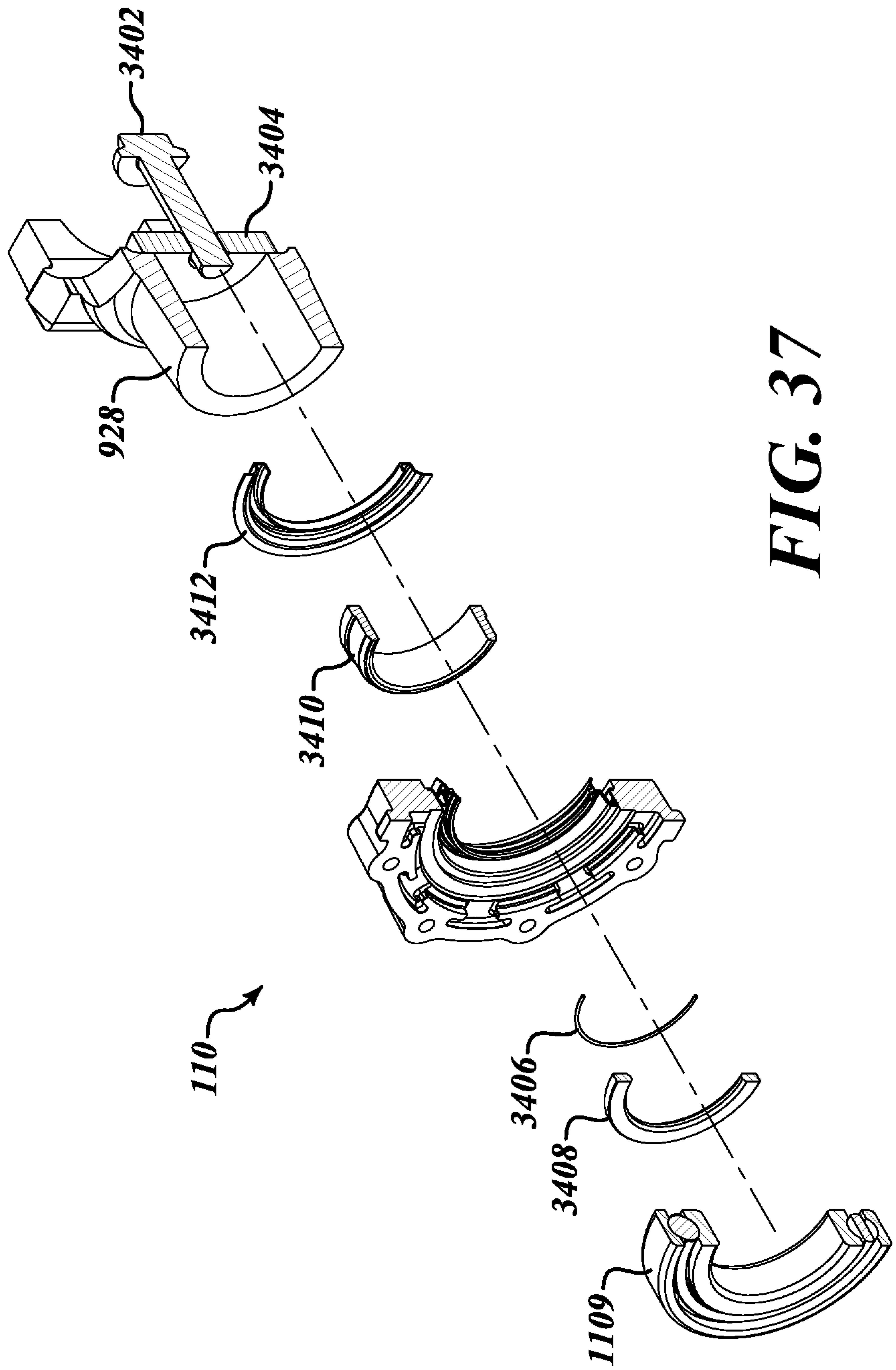

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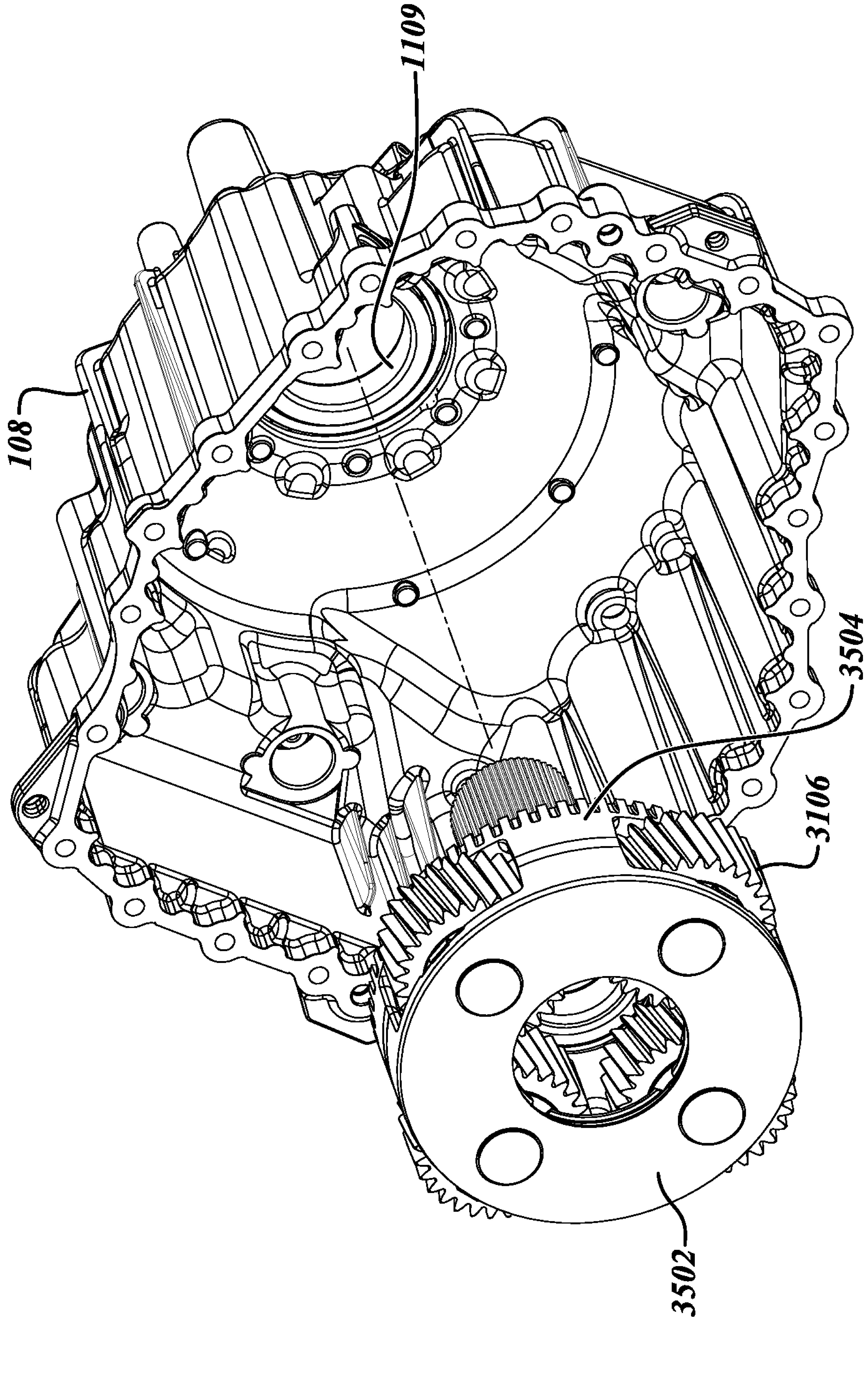

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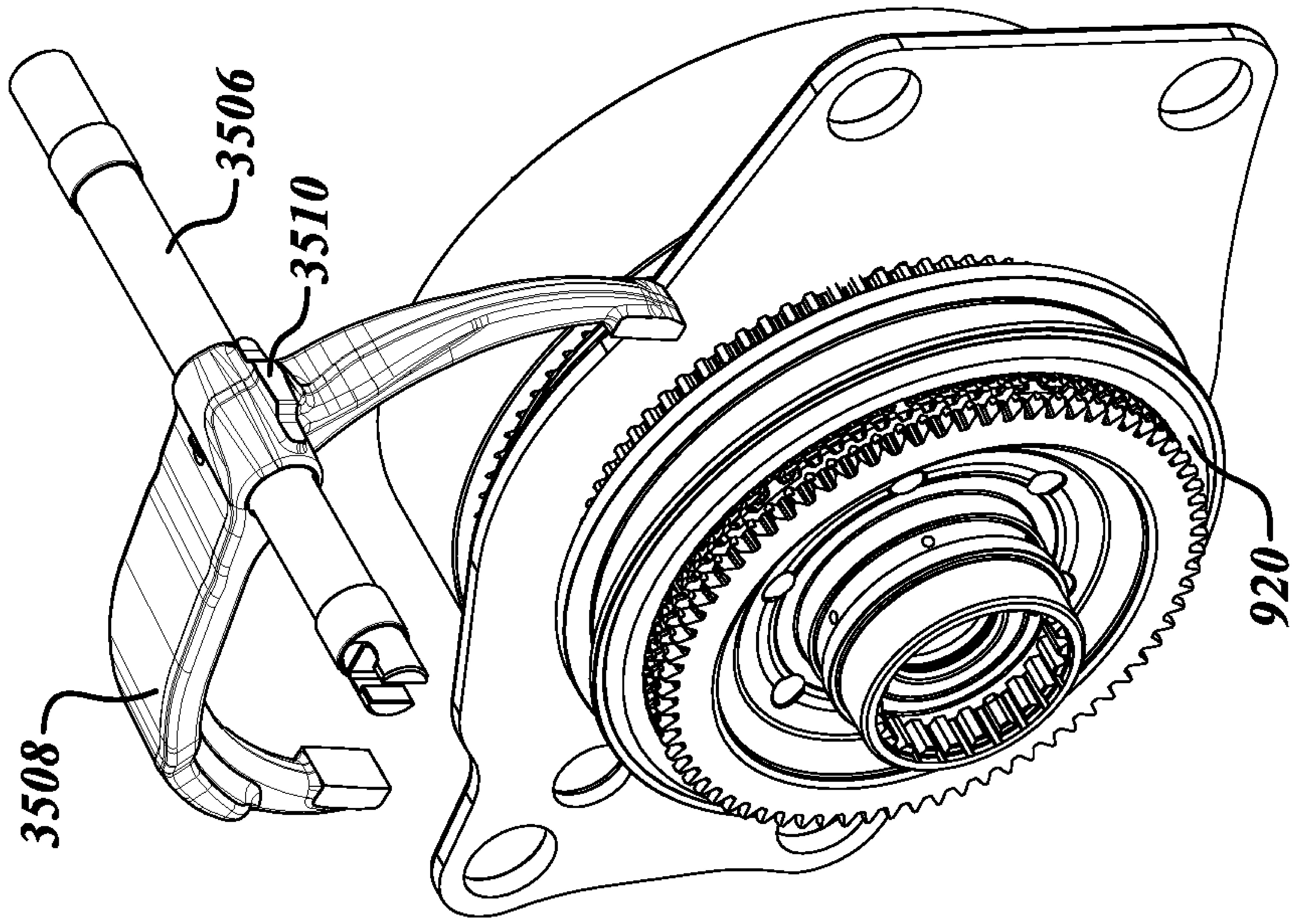

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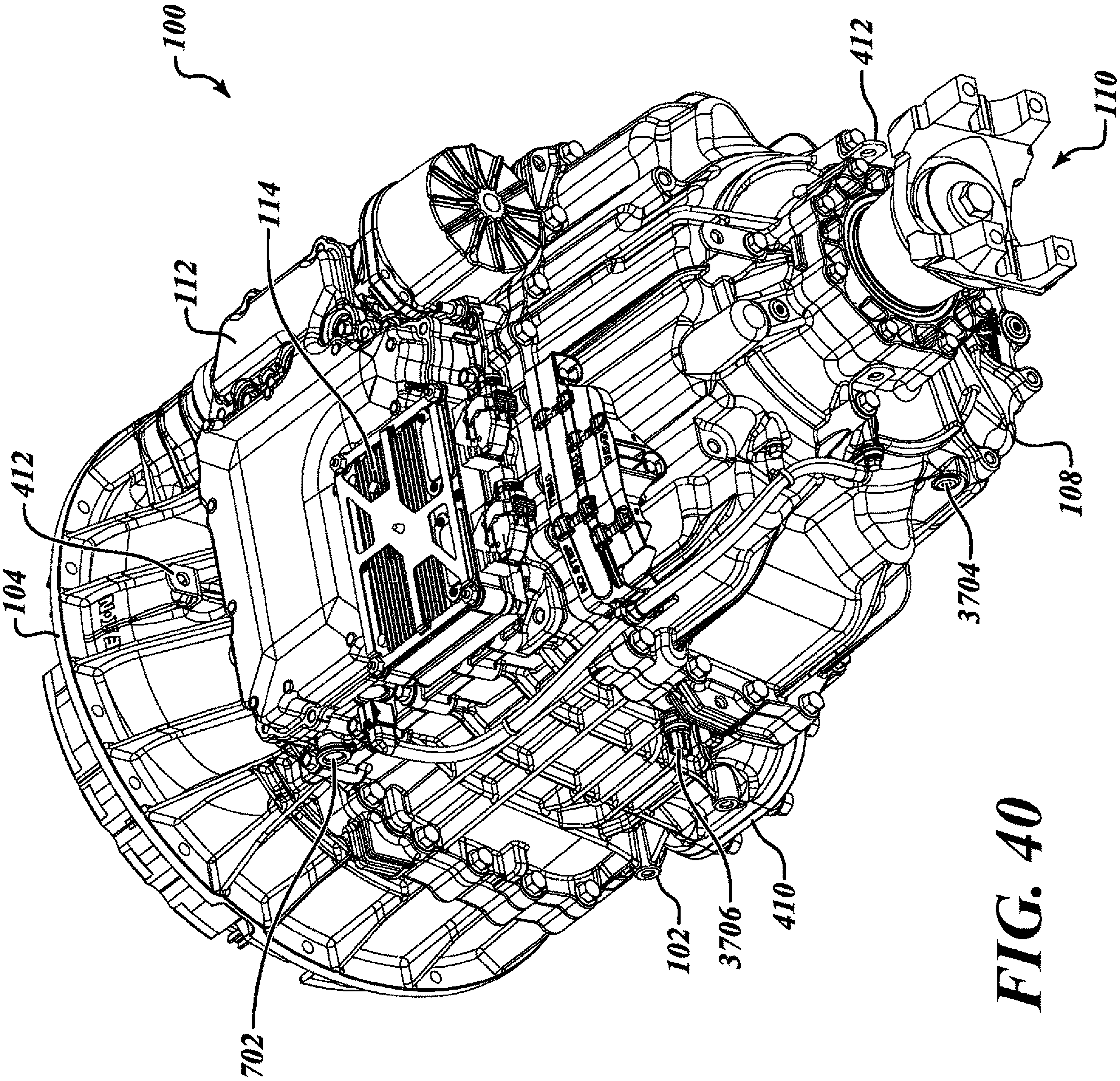

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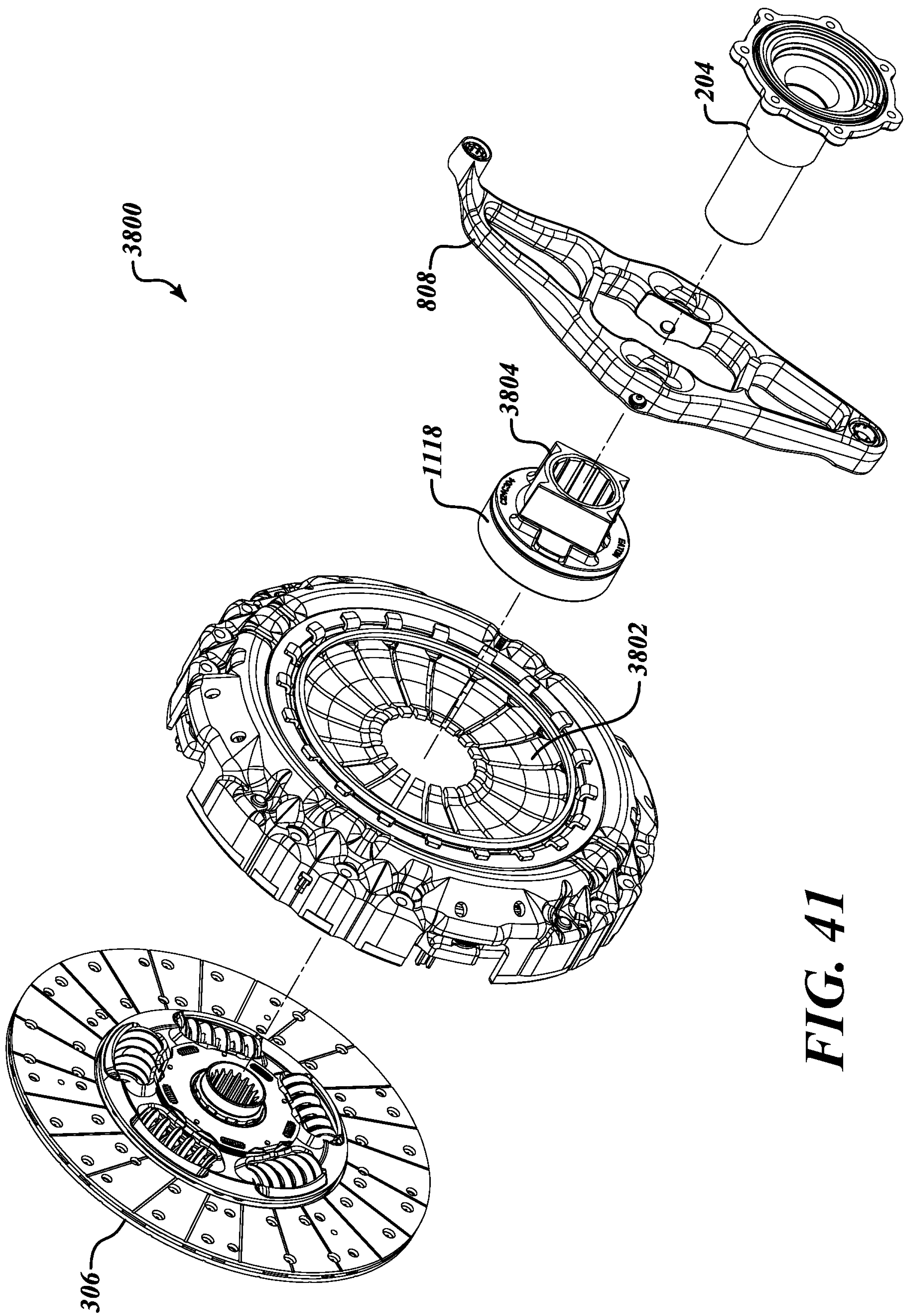

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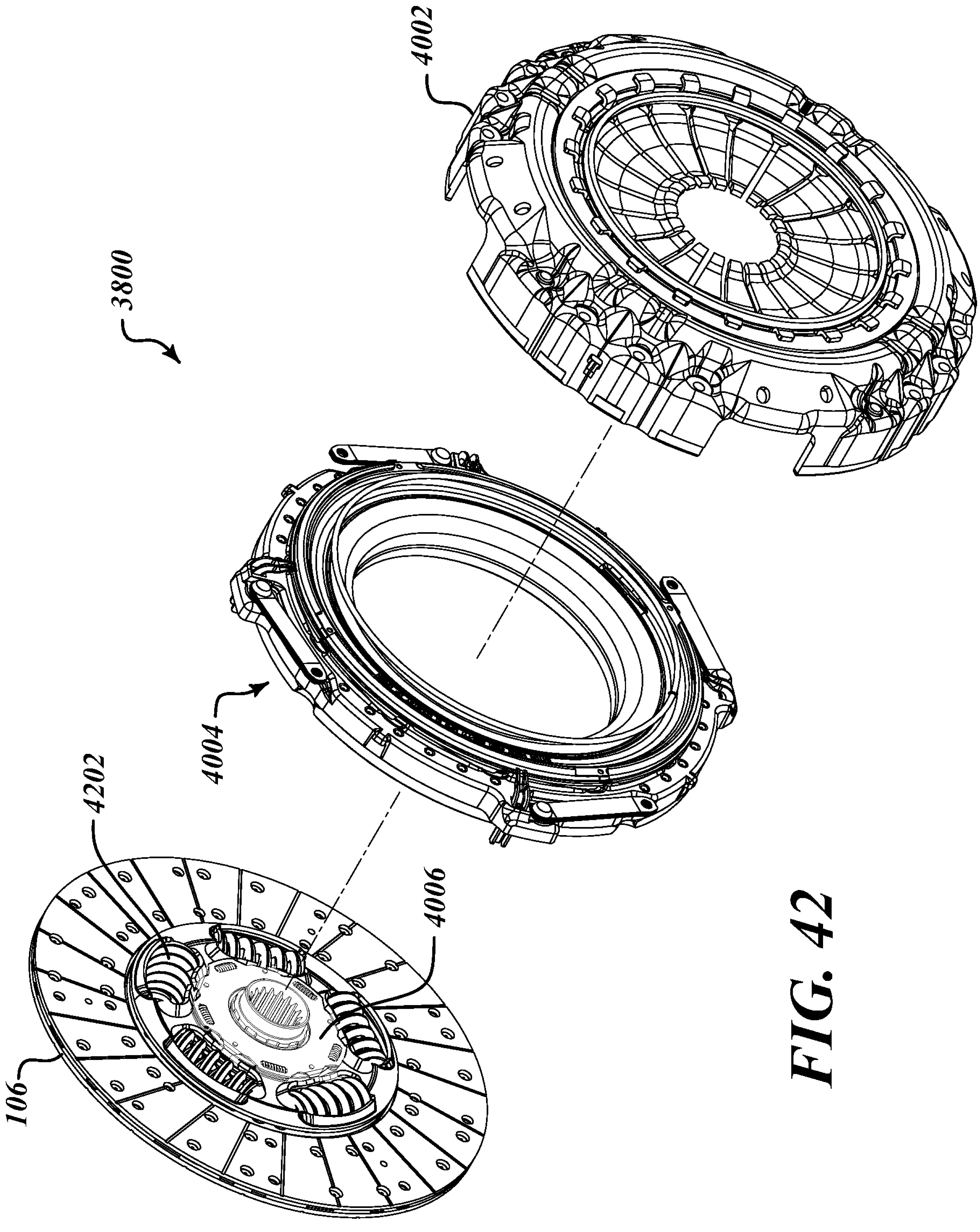

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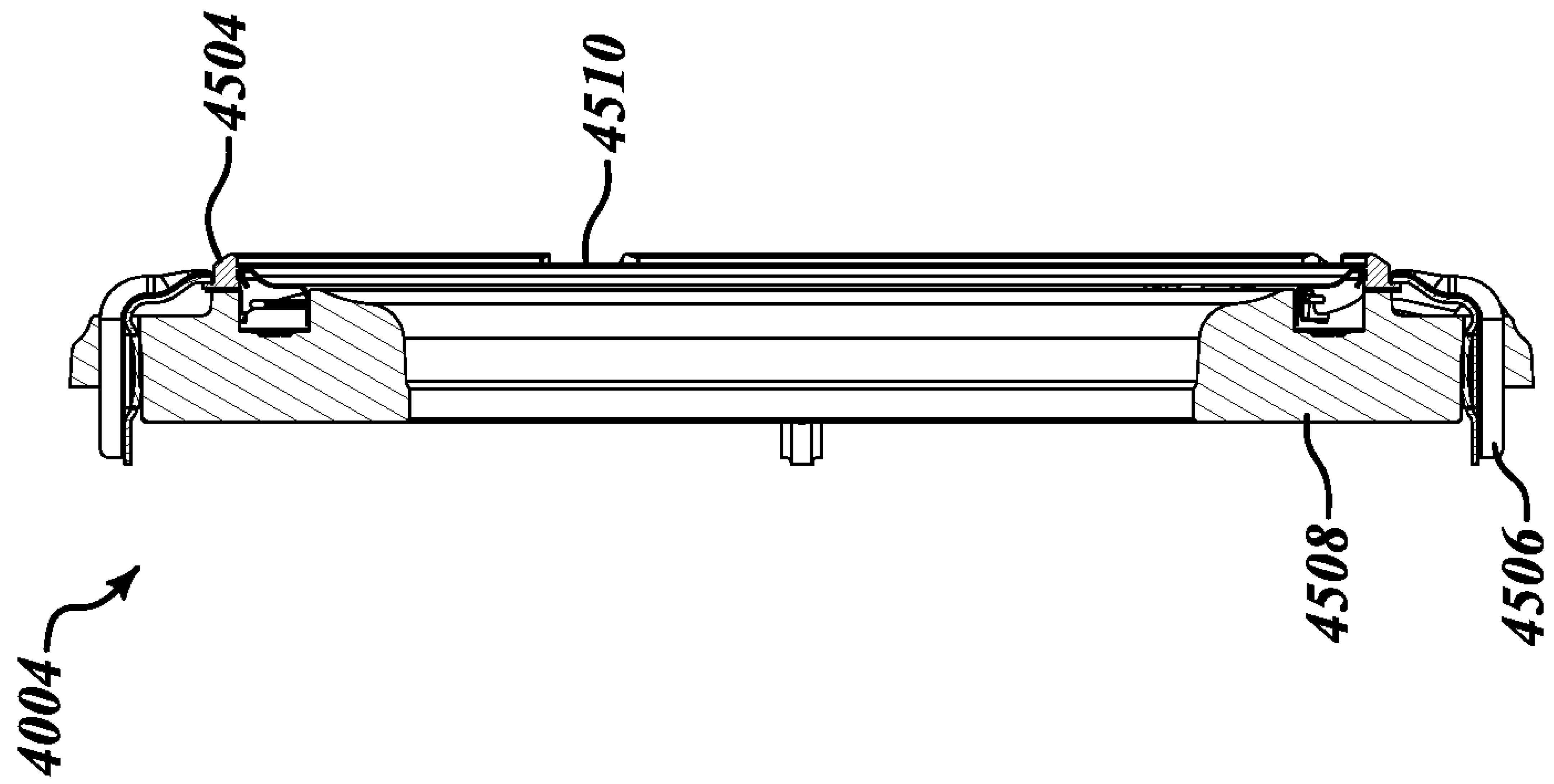

FIG. 44

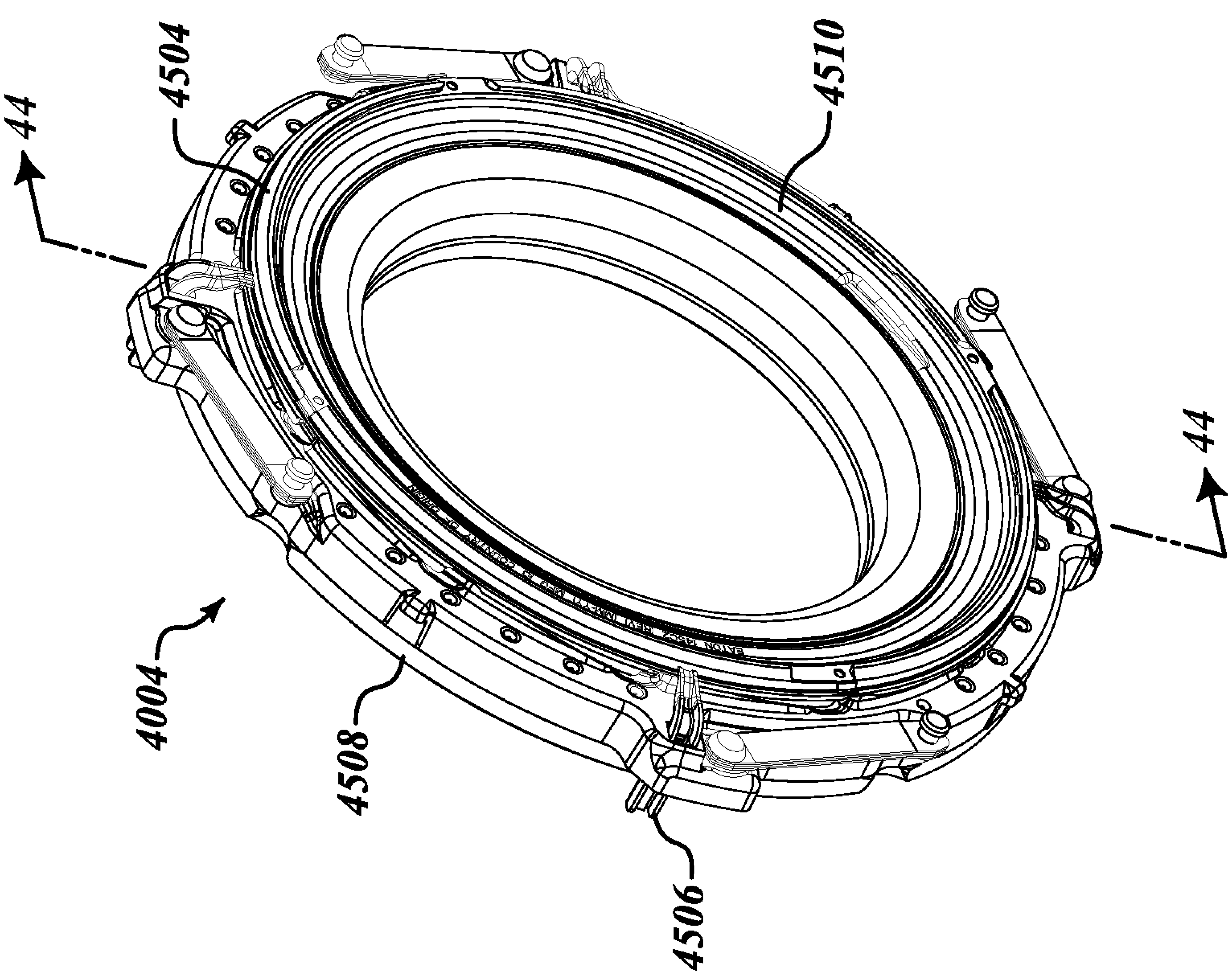

FIG. 43

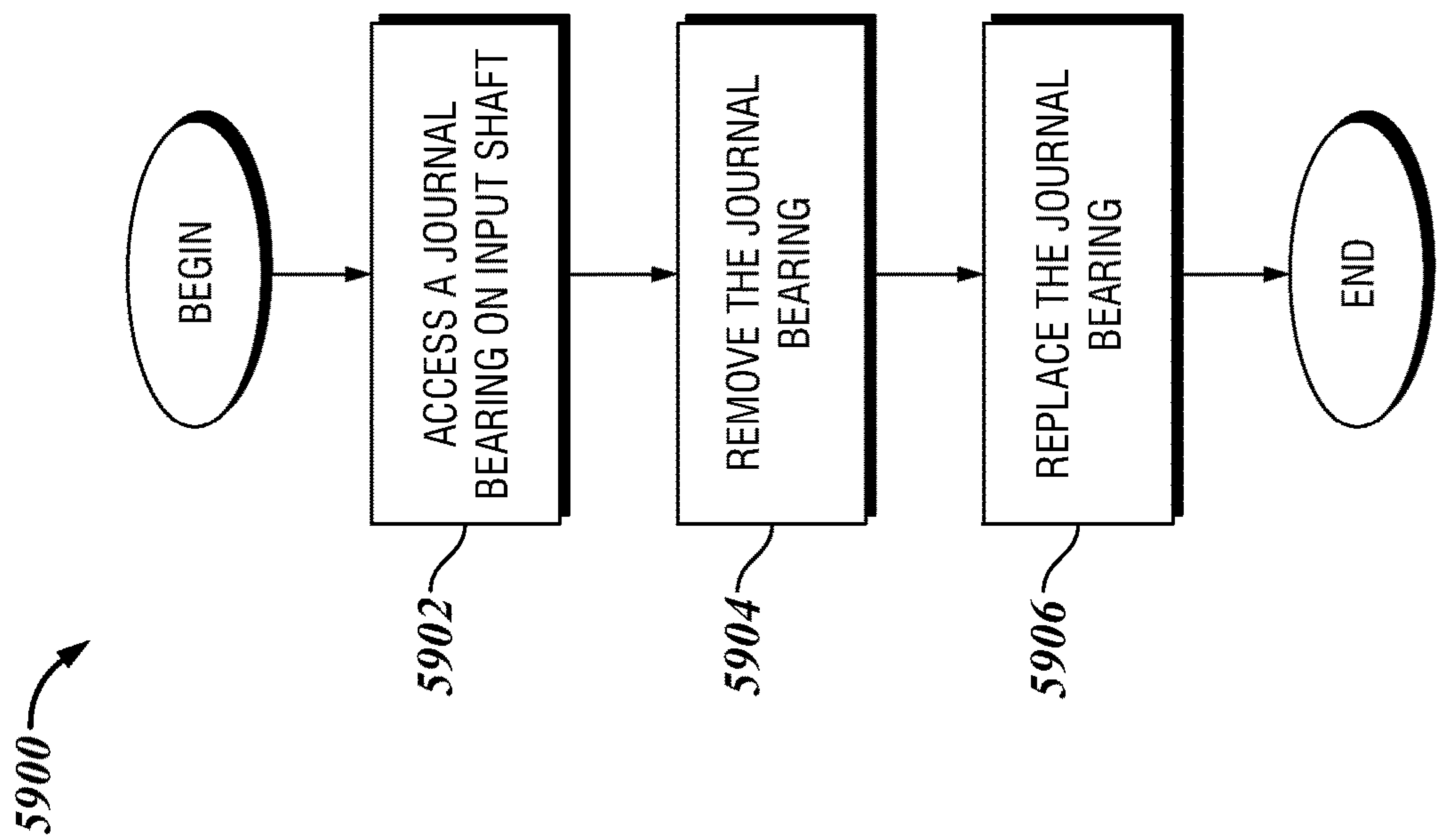
5900
BEGIN
ACCESS A JOURNAL BEARING ON INPUT SHAFT
5902
REMOVE THE JOURNAL BEARING
5904
REPLACE THE JOURNAL BEARING
5906
END

FIG. 46

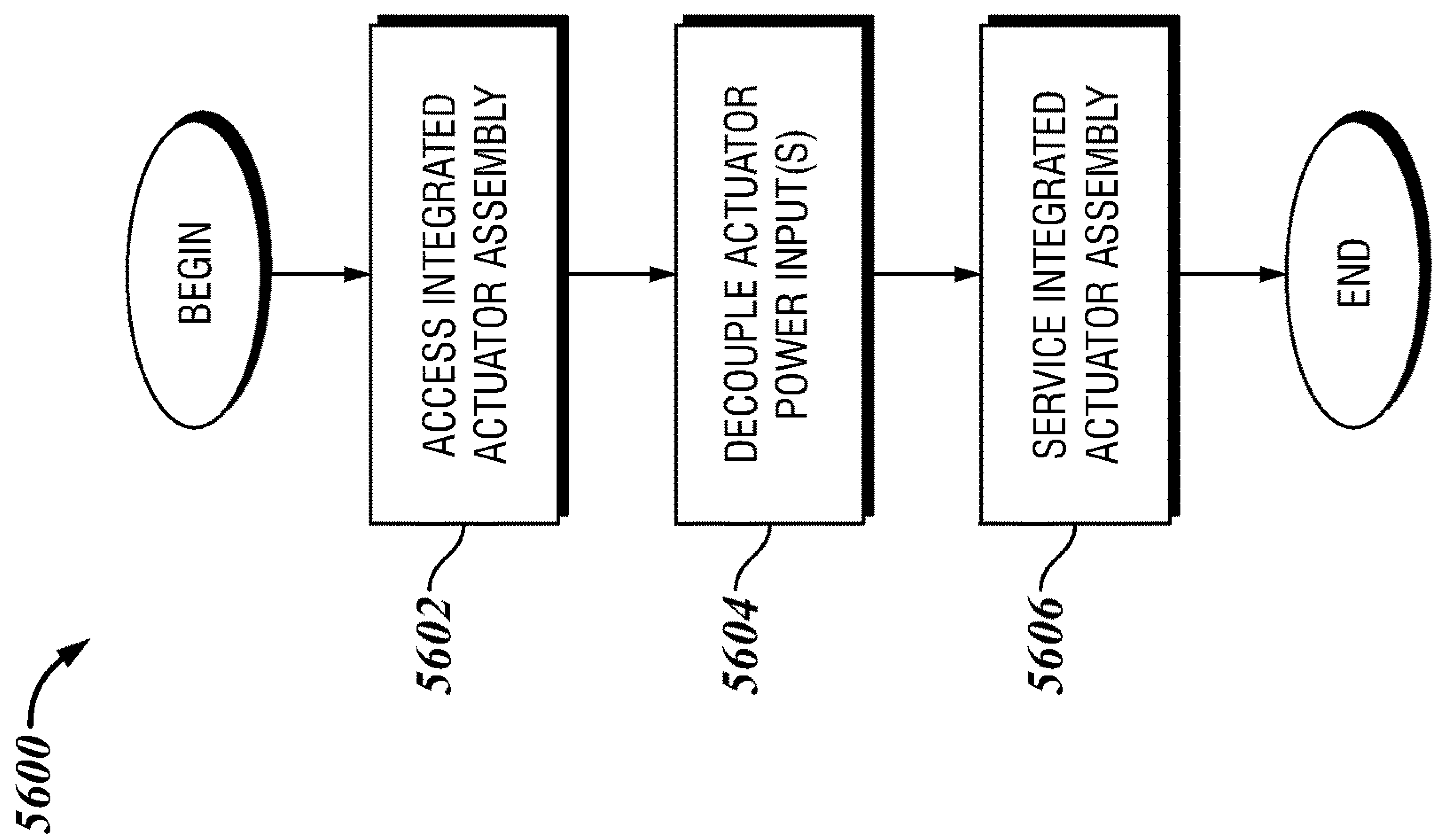
5600
BEGIN
ACCESS INTEGRATED ACTUATOR ASSEMBLY
5602
DECOUPLE ACTUATOR POWER INPUT(S)
5604
SERVICE INTEGRATED ACTUATOR ASSEMBLY
5606
END

FIG. 45

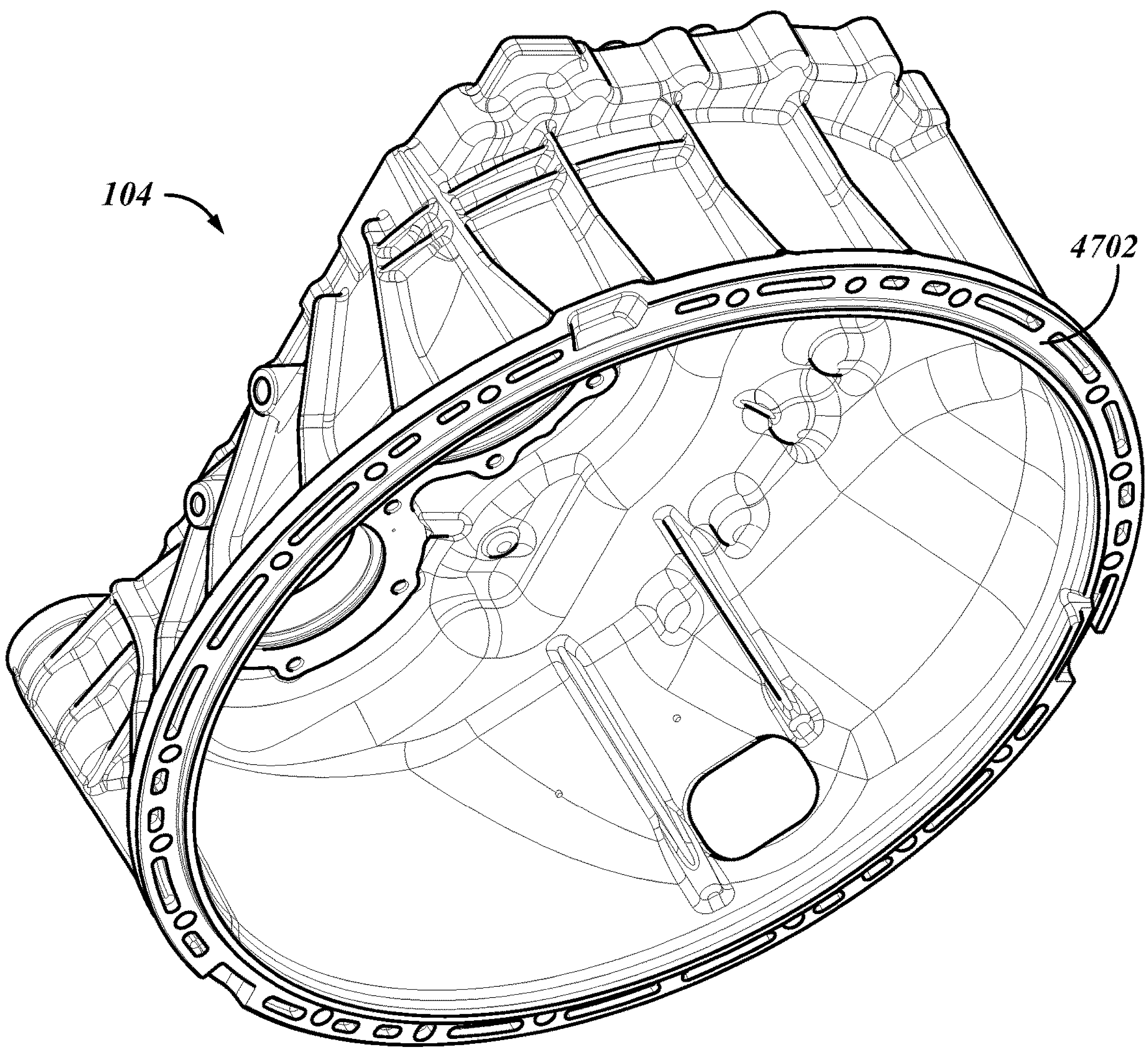

FIG. 47

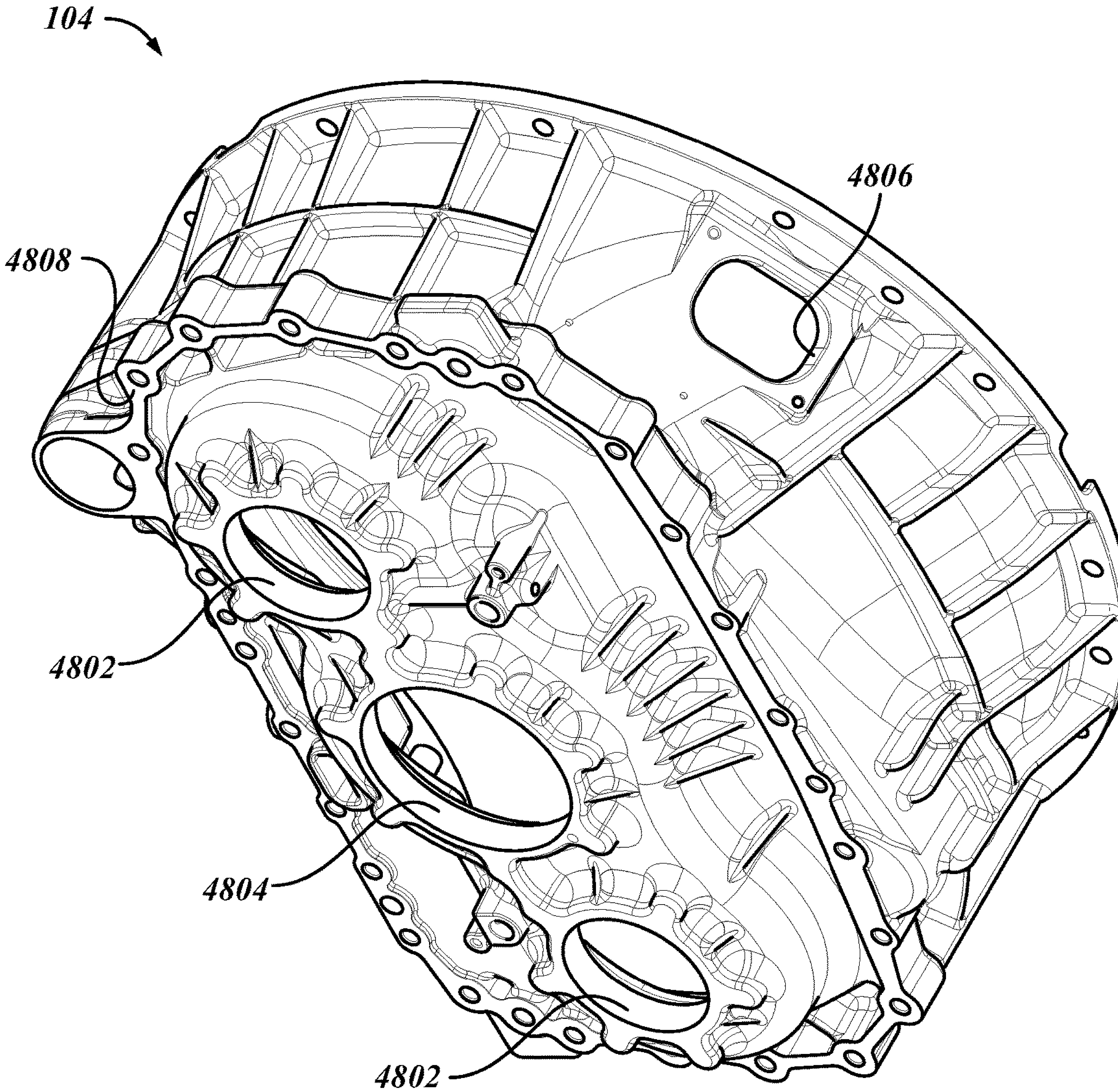

FIG. 48

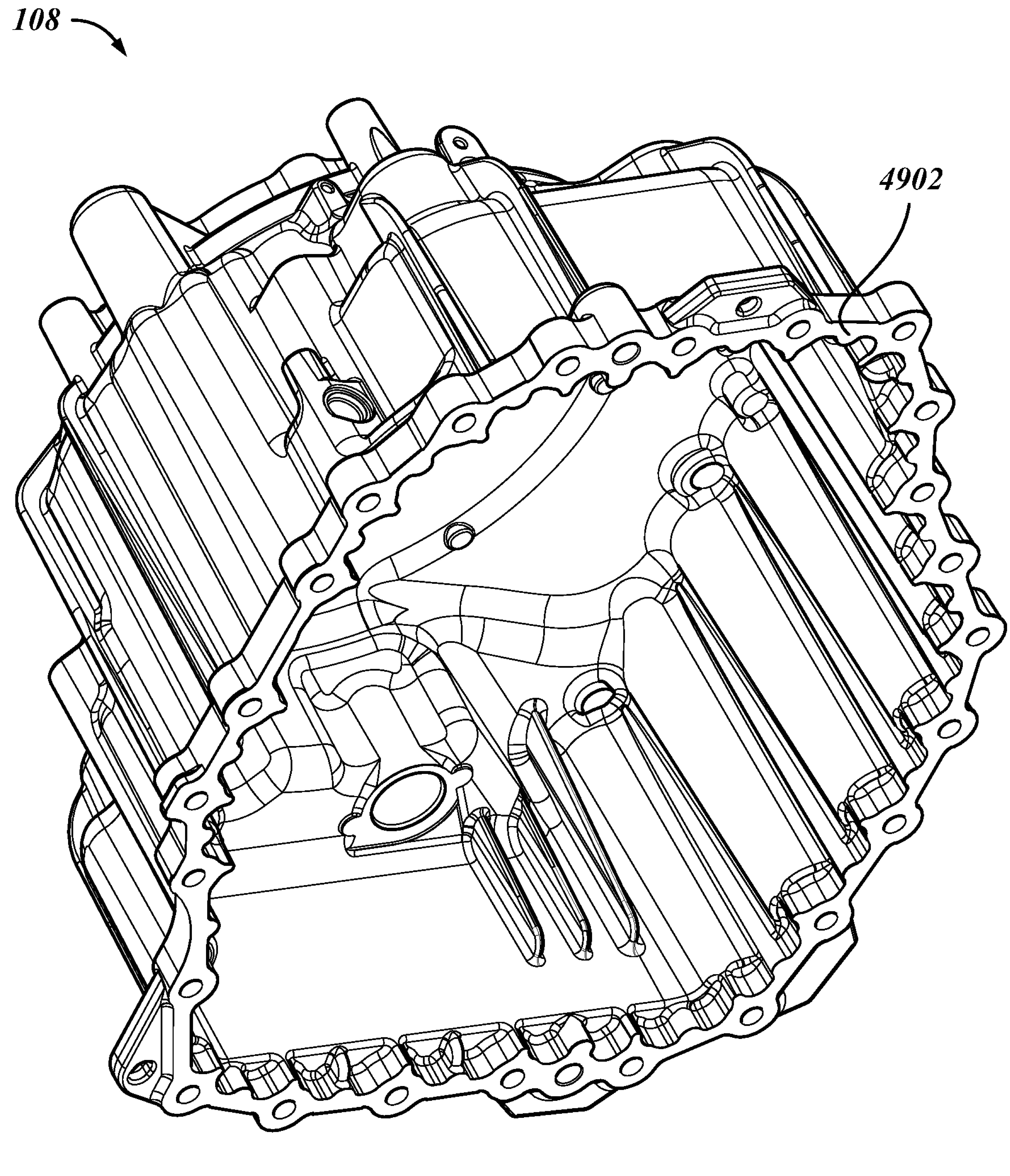

FIG. 49

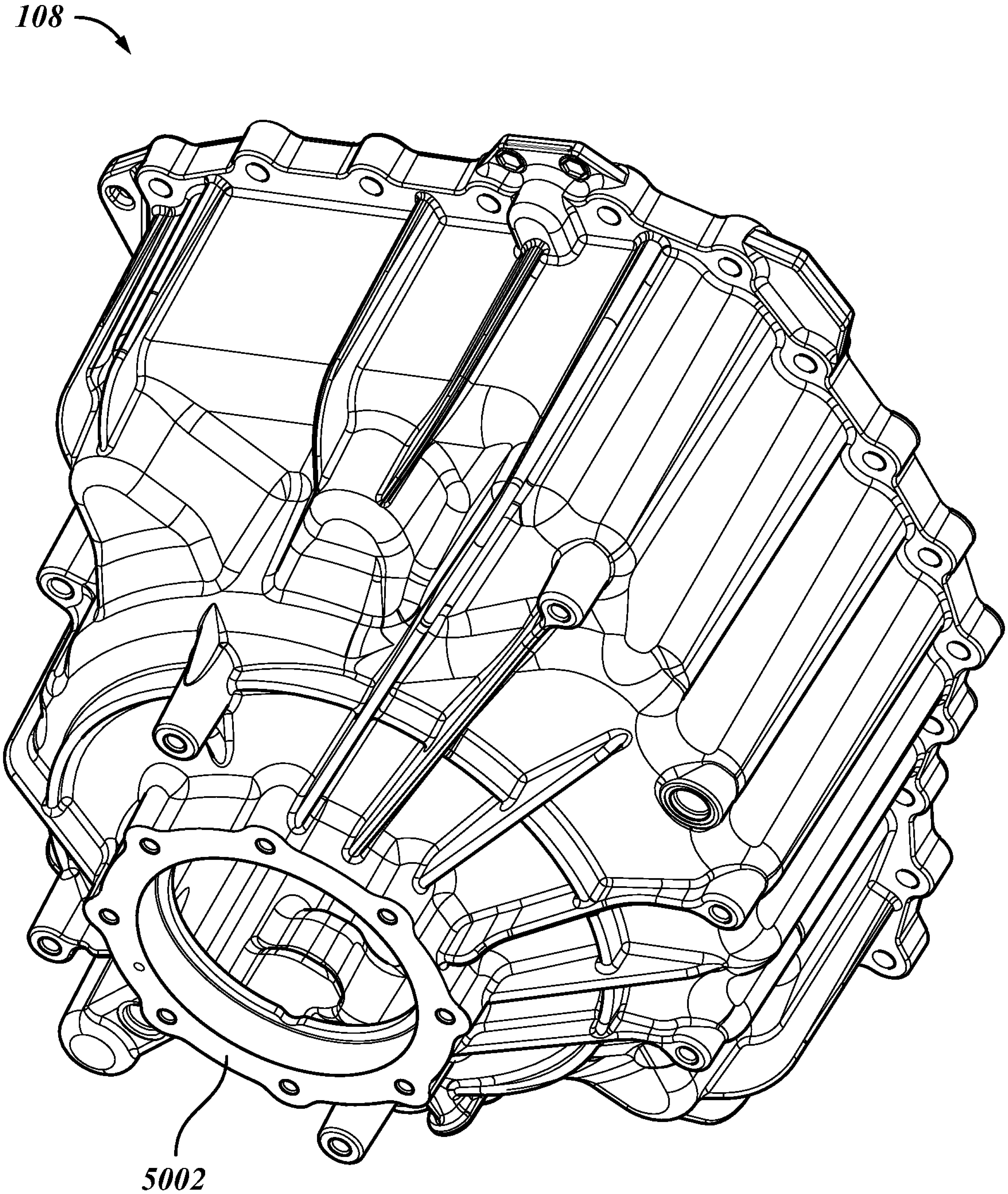

FIG. 50

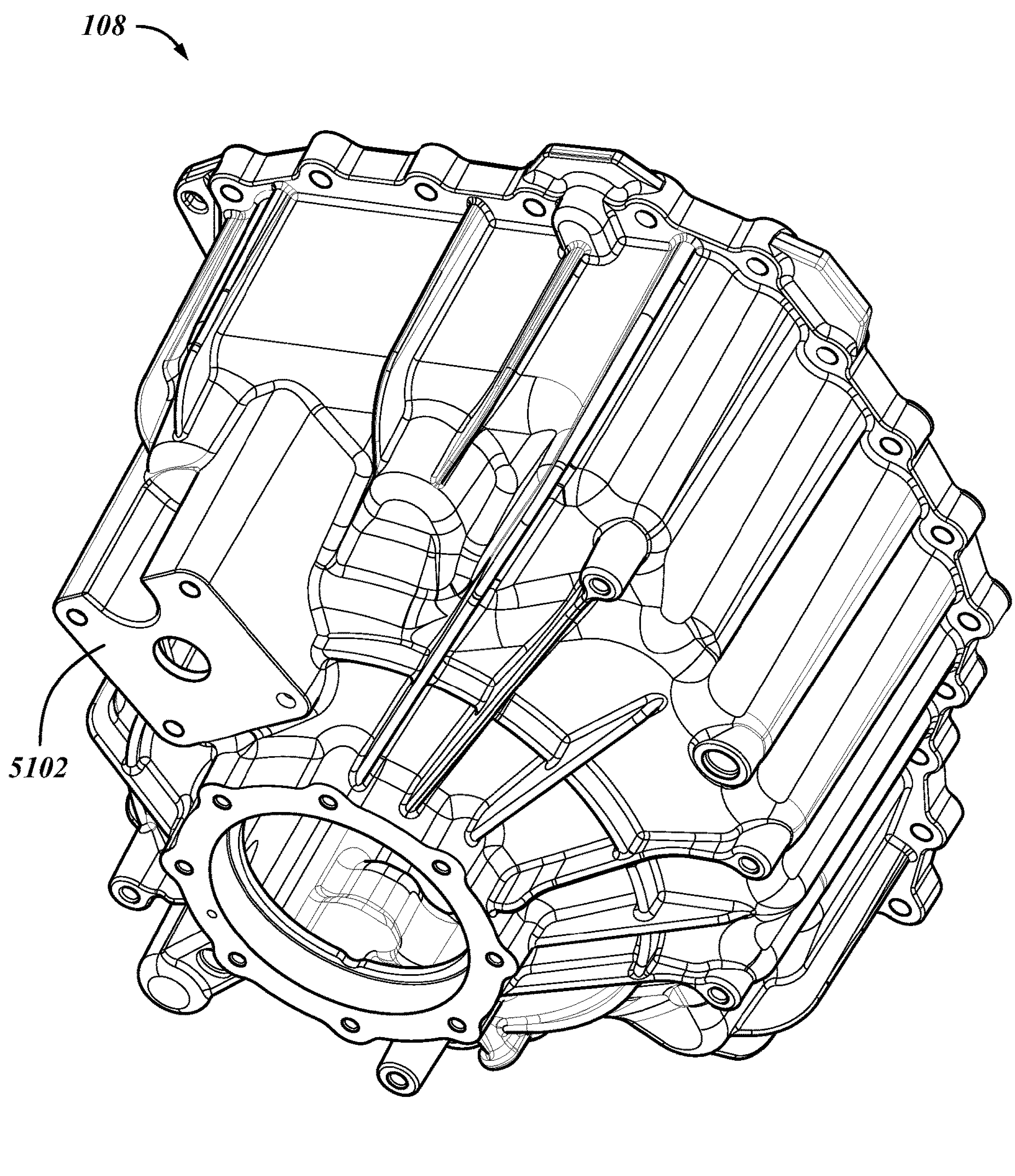

FIG. 51

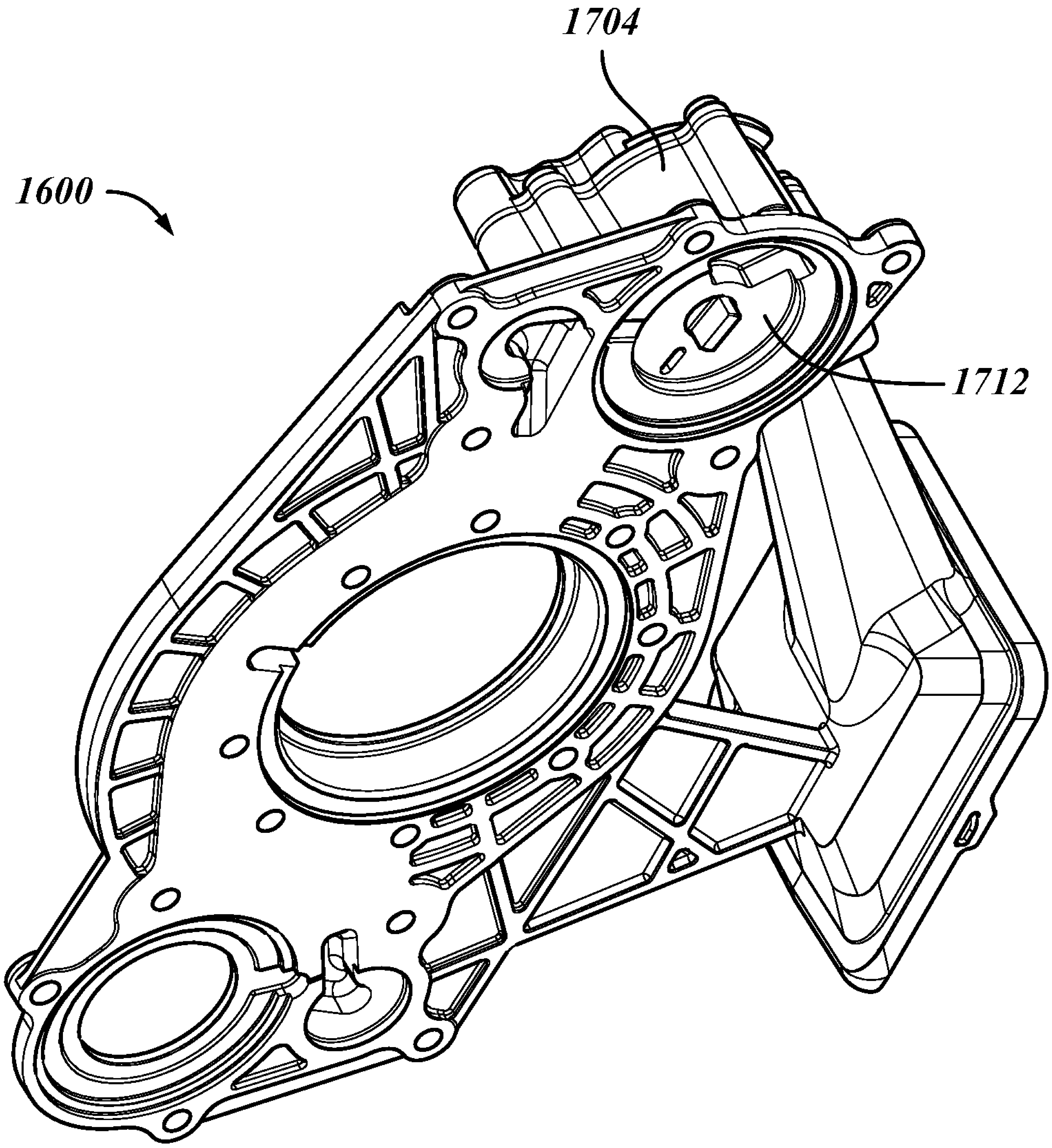

FIG. 52

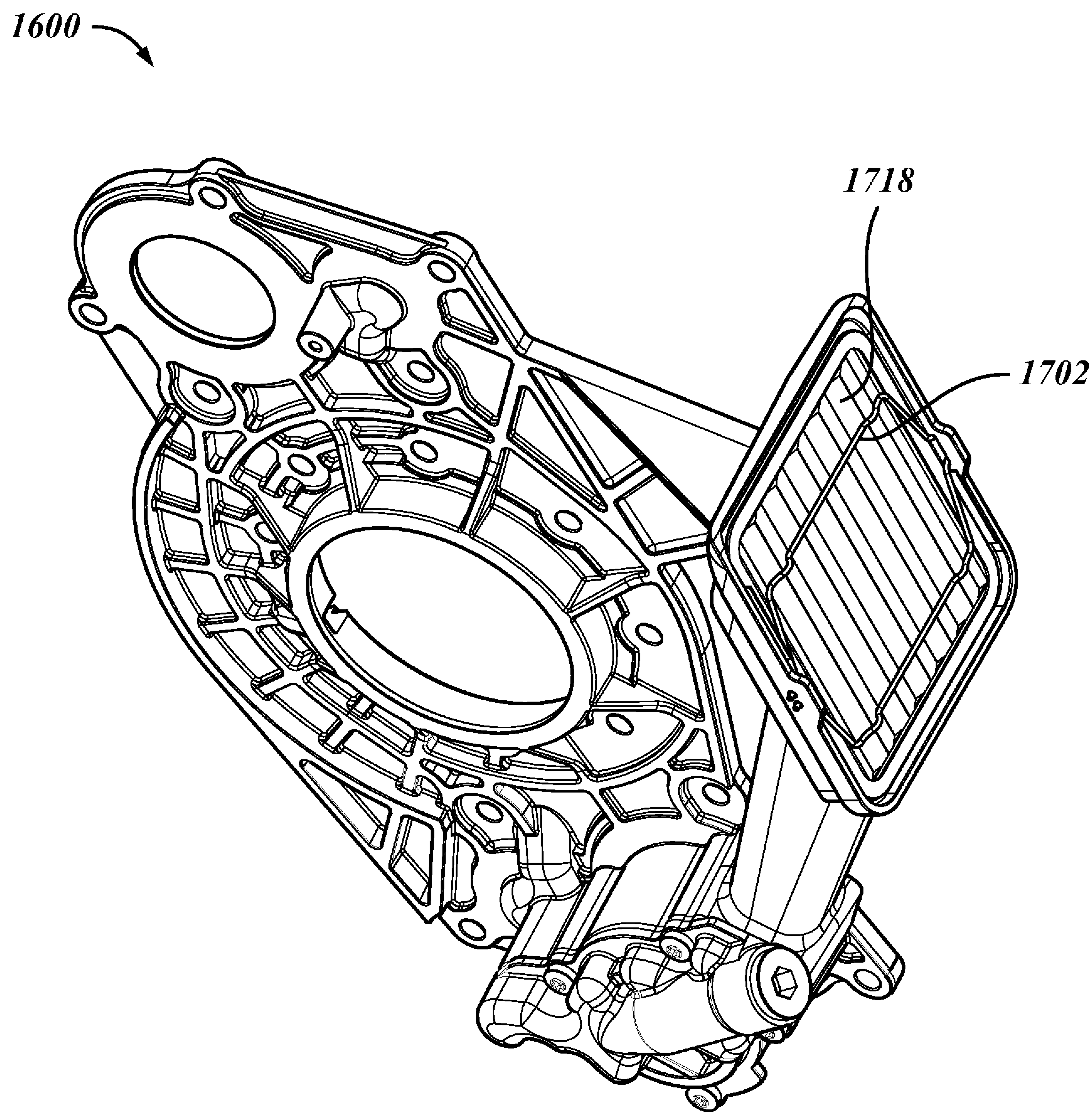

FIG. 53

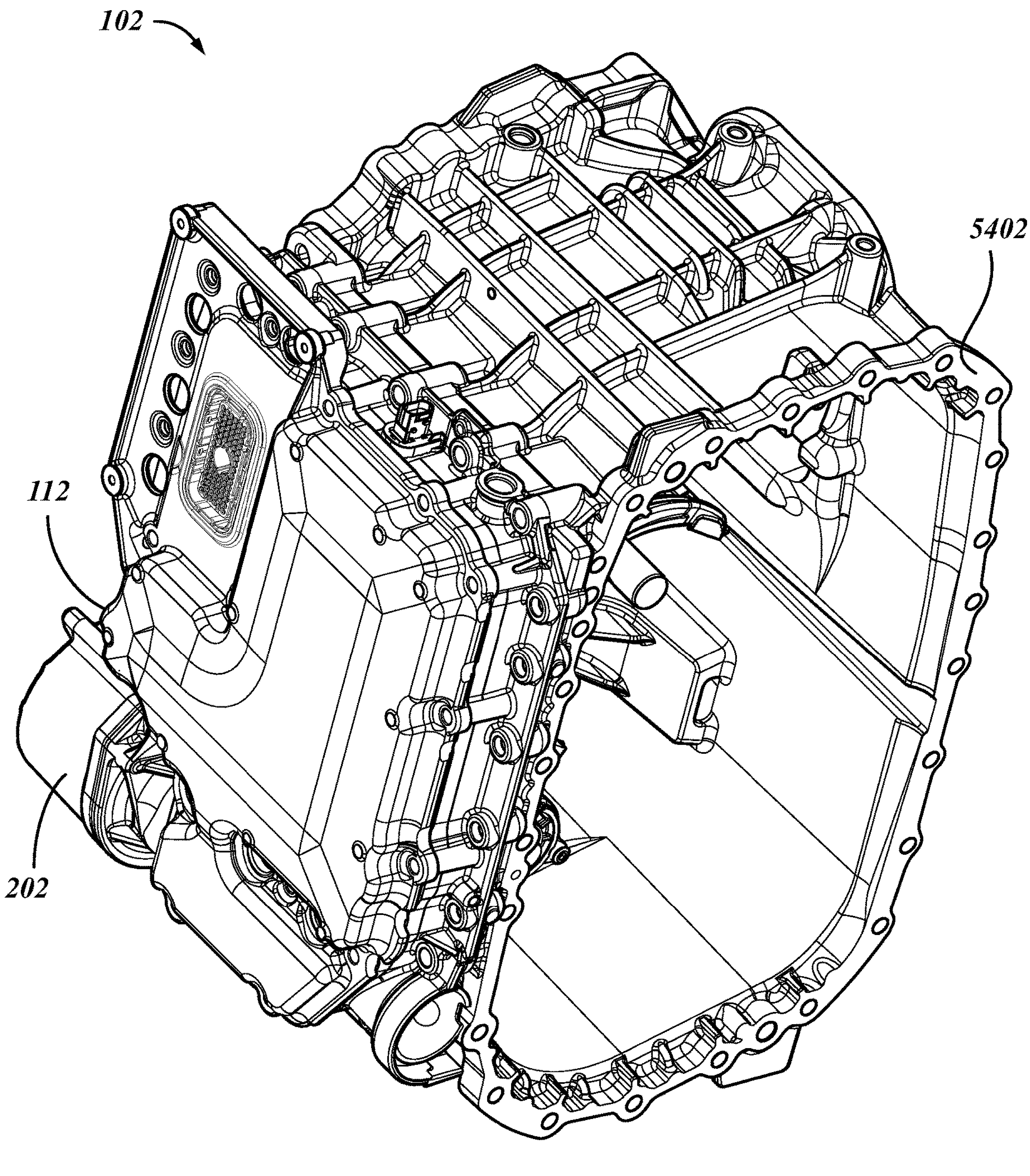

FIG. 54

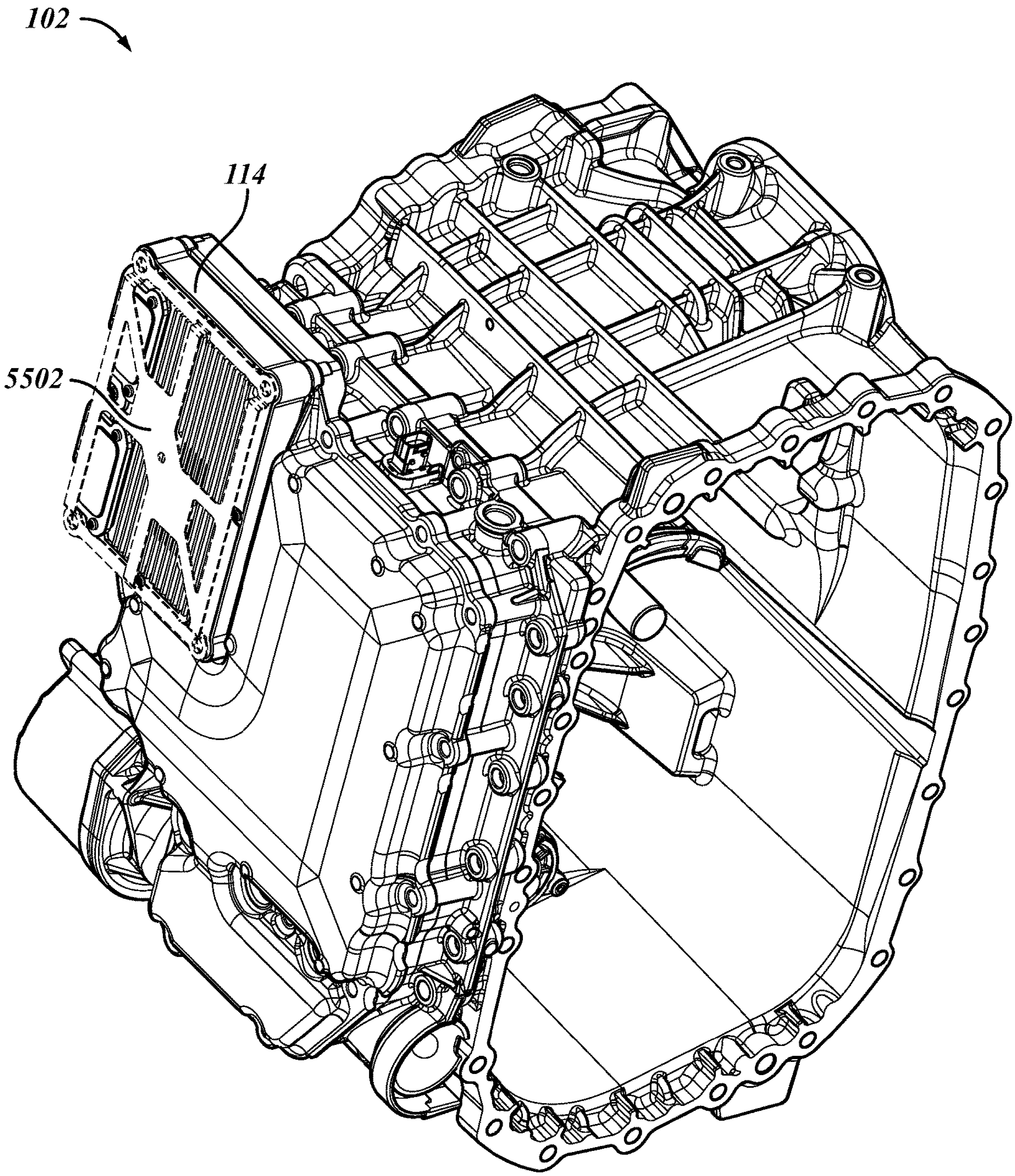

FIG. 55

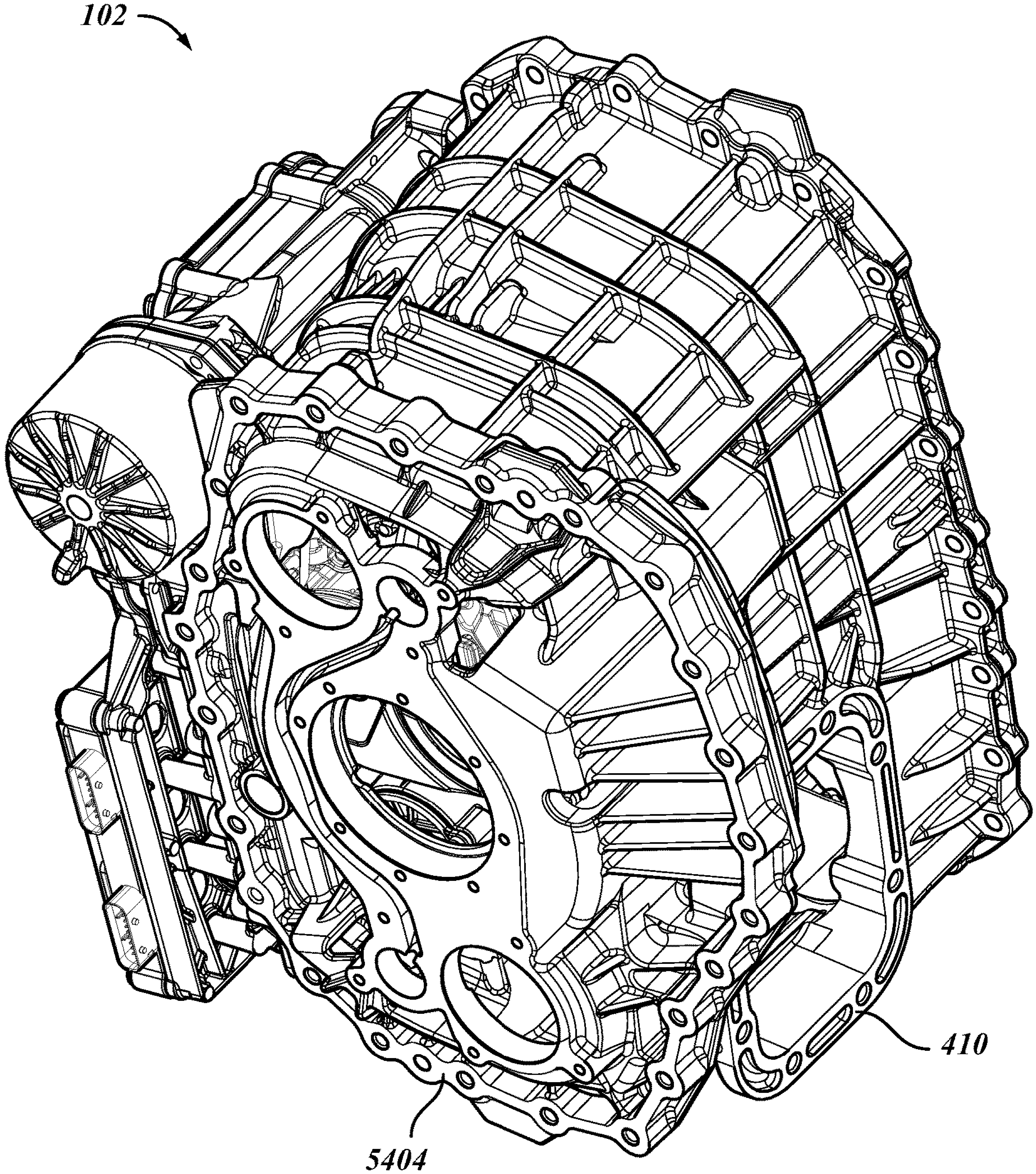

FIG. 56

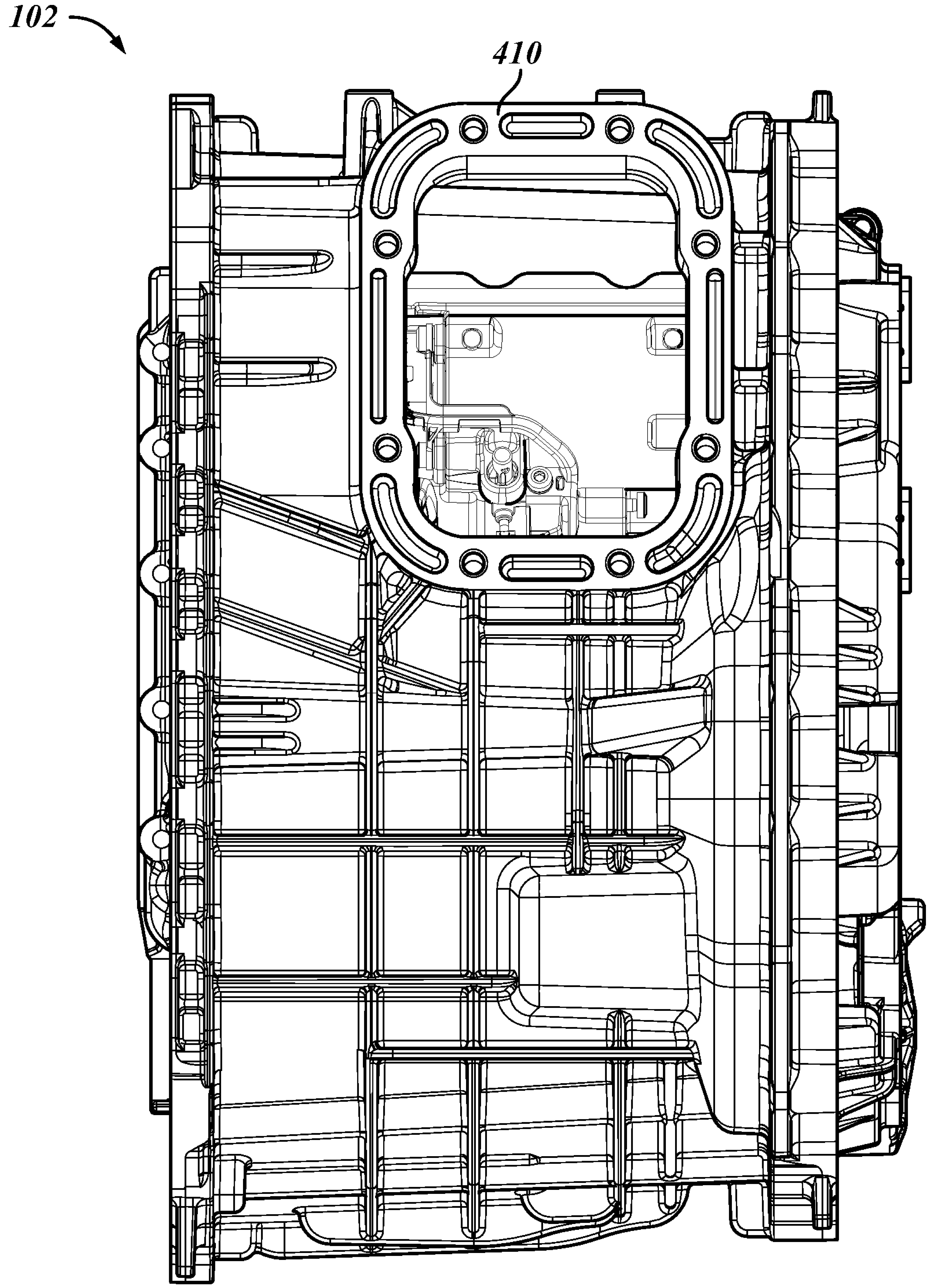

FIG. 57

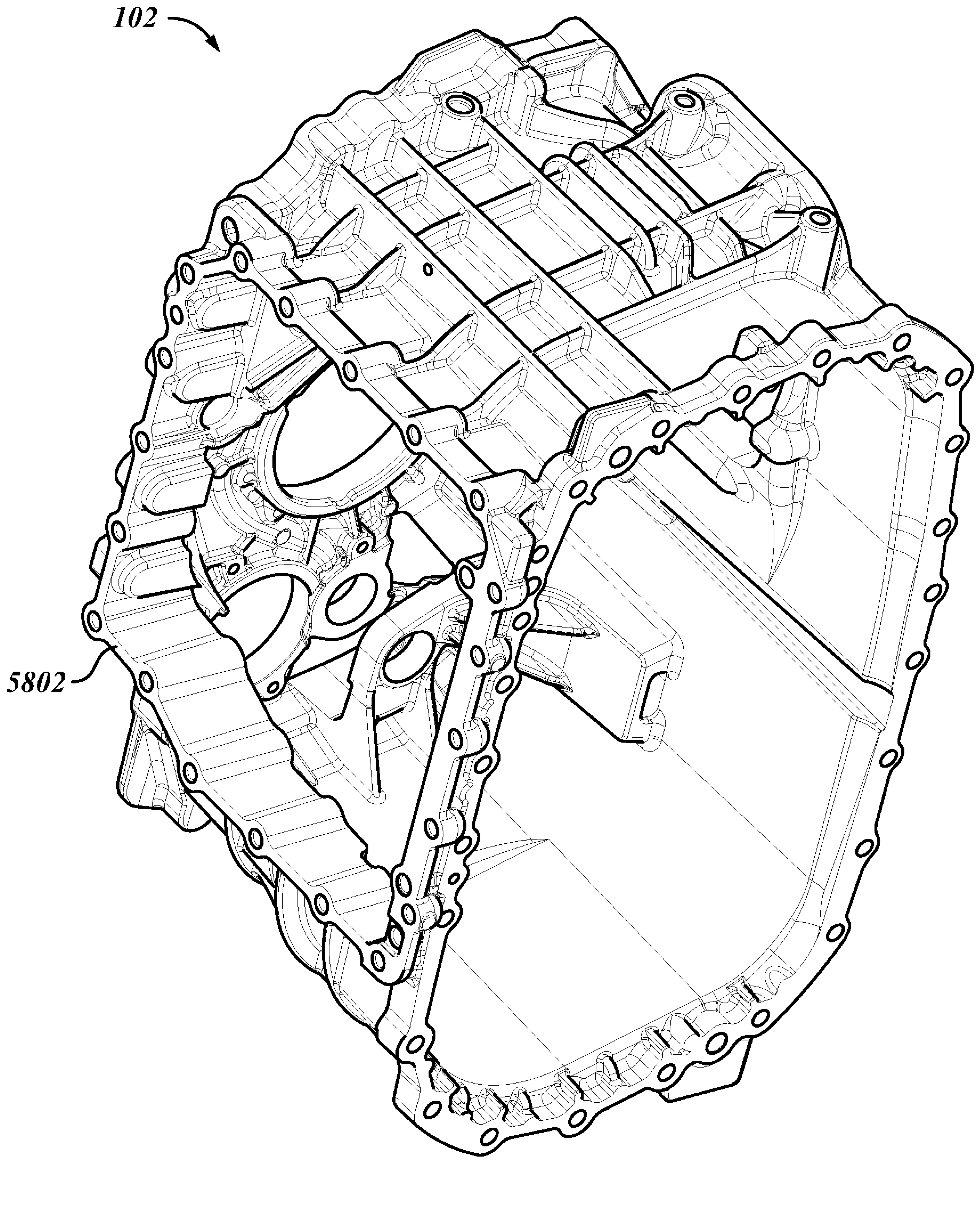

FIG. 58

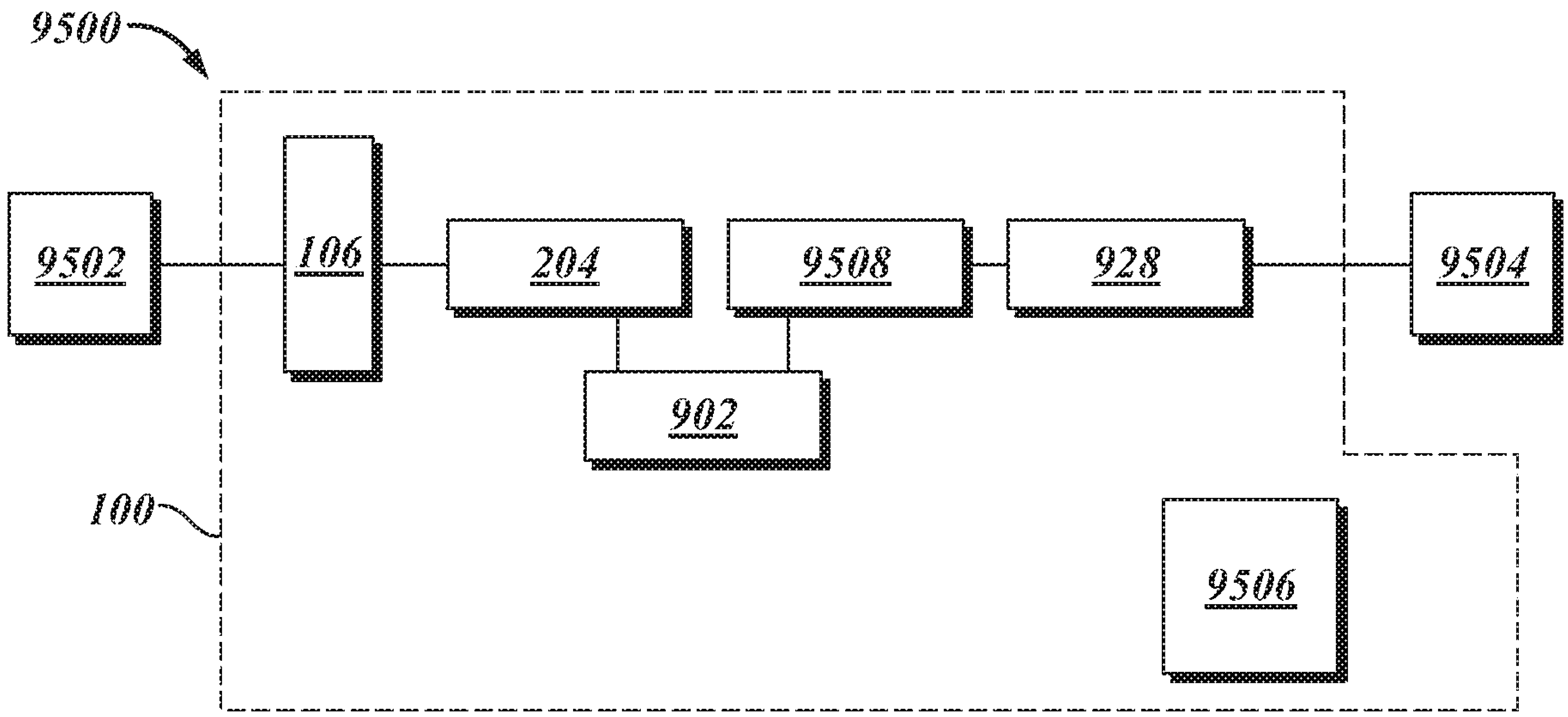
9500
9502
106
204
9508
928
9504
902
100
9506

FIG. 59

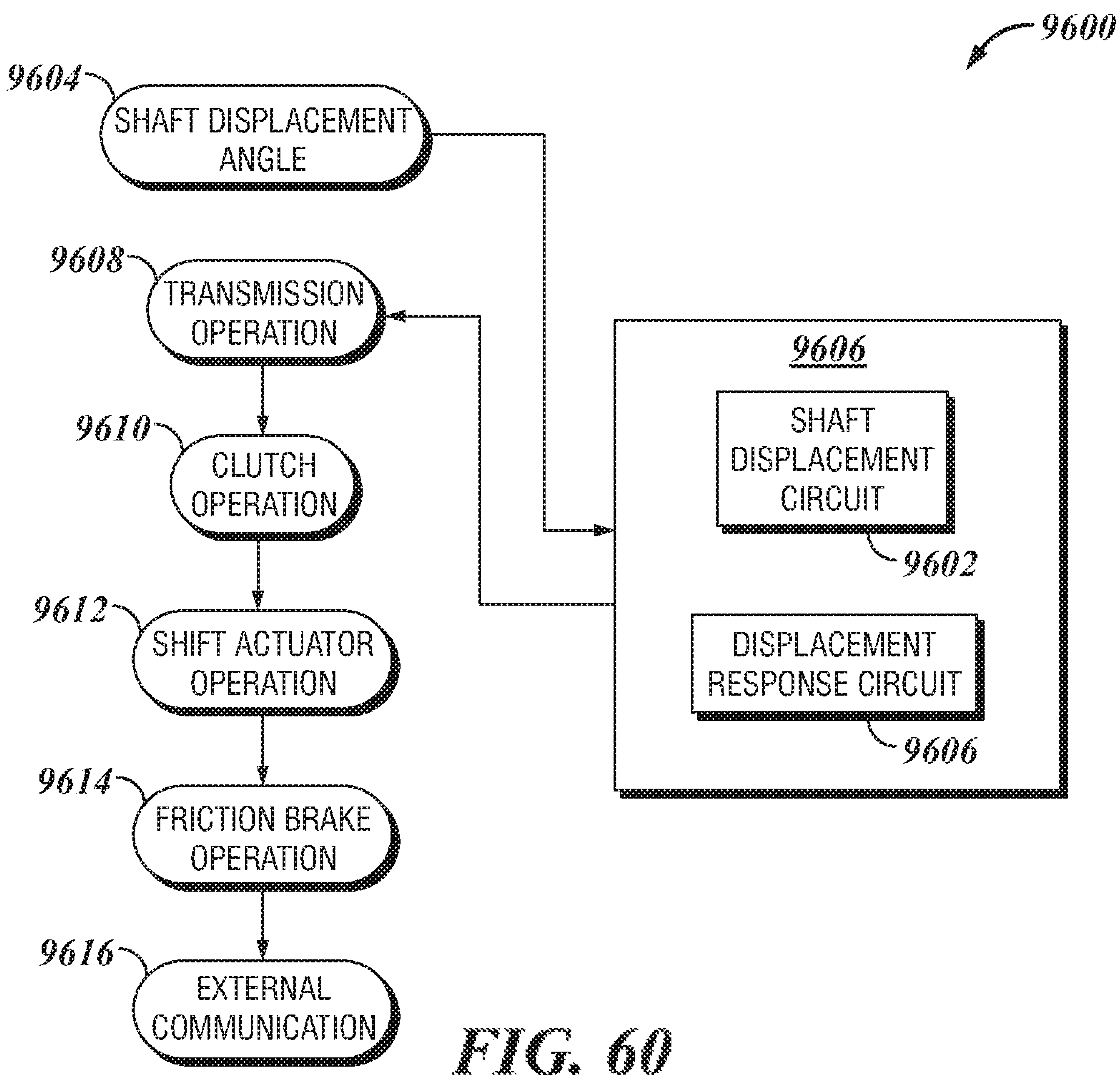
9600
9604
SHAFT DISPLACEMENT ANGLE
9608
TRANSMISSION OPERATION
9610
CLUTCH OPERATION
9612
SHIFT ACTUATOR OPERATION
9614
FRICTION BRAKE OPERATION
9616
EXTERNAL COMMUNICATION
9606
SHAFT DISPLACEMENT CIRCUIT
9602
DISPLACEMENT RESPONSE CIRCUIT
9606

FIG. 60

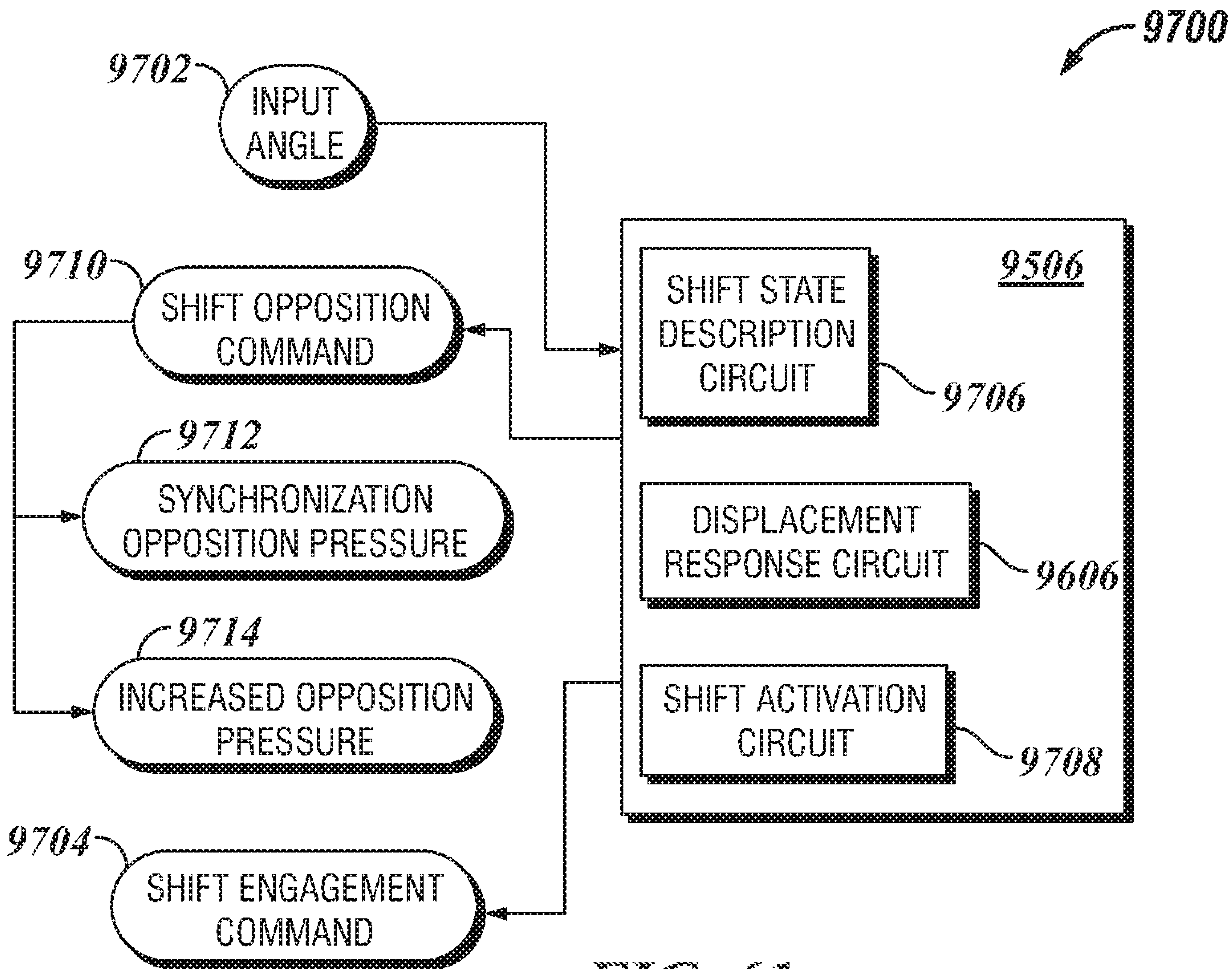
9700
9702
INPUT ANGLE
9710
SHIFT OPPOSITION COMMAND
9712
SYNCHRONIZATION OPPOSITION PRESSURE
9714
INCREASED OPPOSITION PRESSURE
9704
SHIFT ENGAGEMENT COMMAND
9506
SHIFT STATE DESCRIPTION CIRCUIT
9706
DISPLACEMENT RESPONSE CIRCUIT
9606
SHIFT ACTIVATION CIRCUIT
9708

FIG. 61

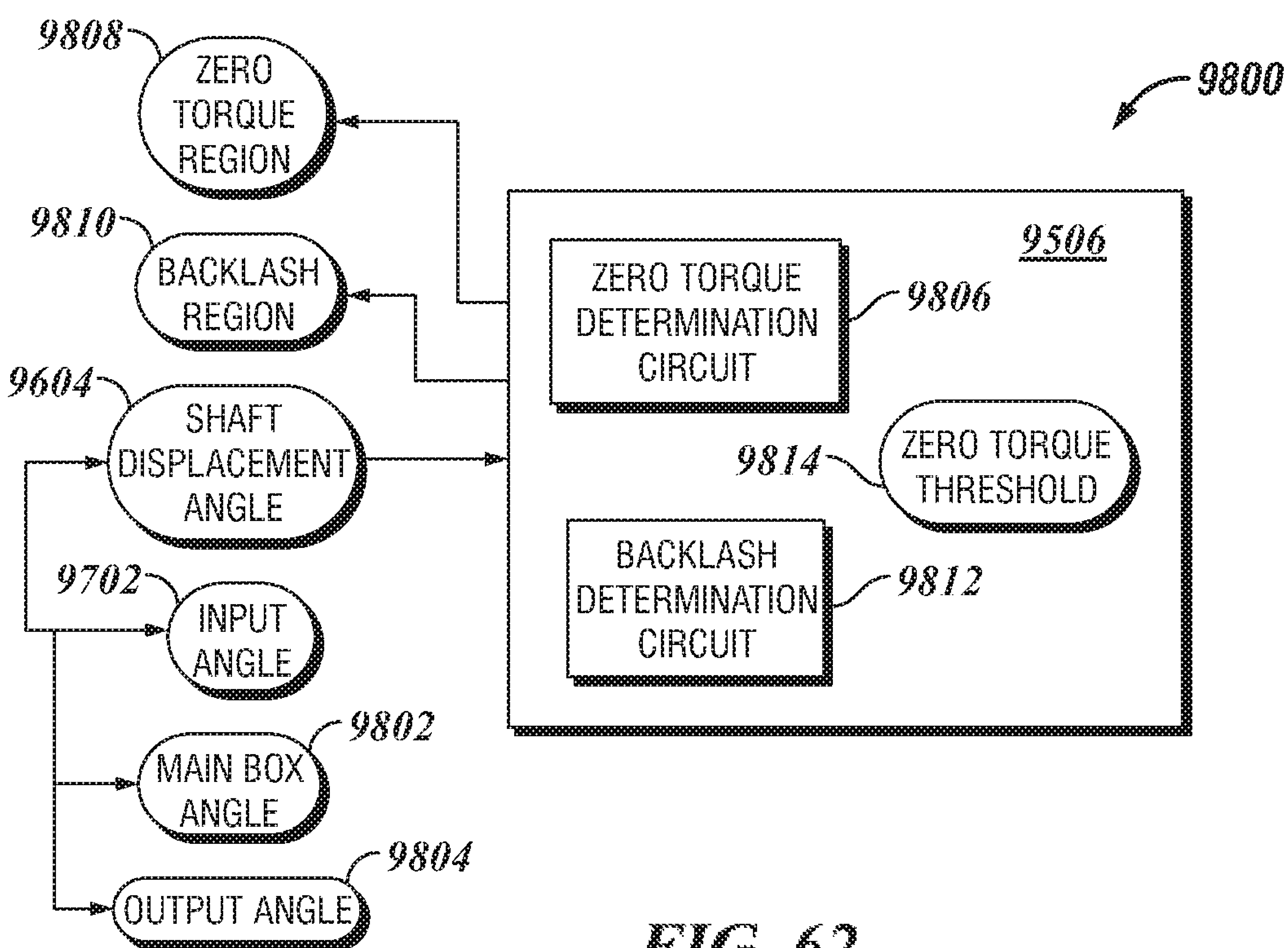
9800
9808
ZERO TORQUE REGION
9810
BACKLASH REGION
9604
SHAFT DISPLACEMENT ANGLE
9702
INPUT ANGLE
9802
MAIN BOX ANGLE
9804
OUTPUT ANGLE
9506
ZERO TORQUE DETERMINATION CIRCUIT
9806
9814
ZERO TORQUE THRESHOLD
BACKLASH DETERMINATION CIRCUIT
9812

FIG. 62

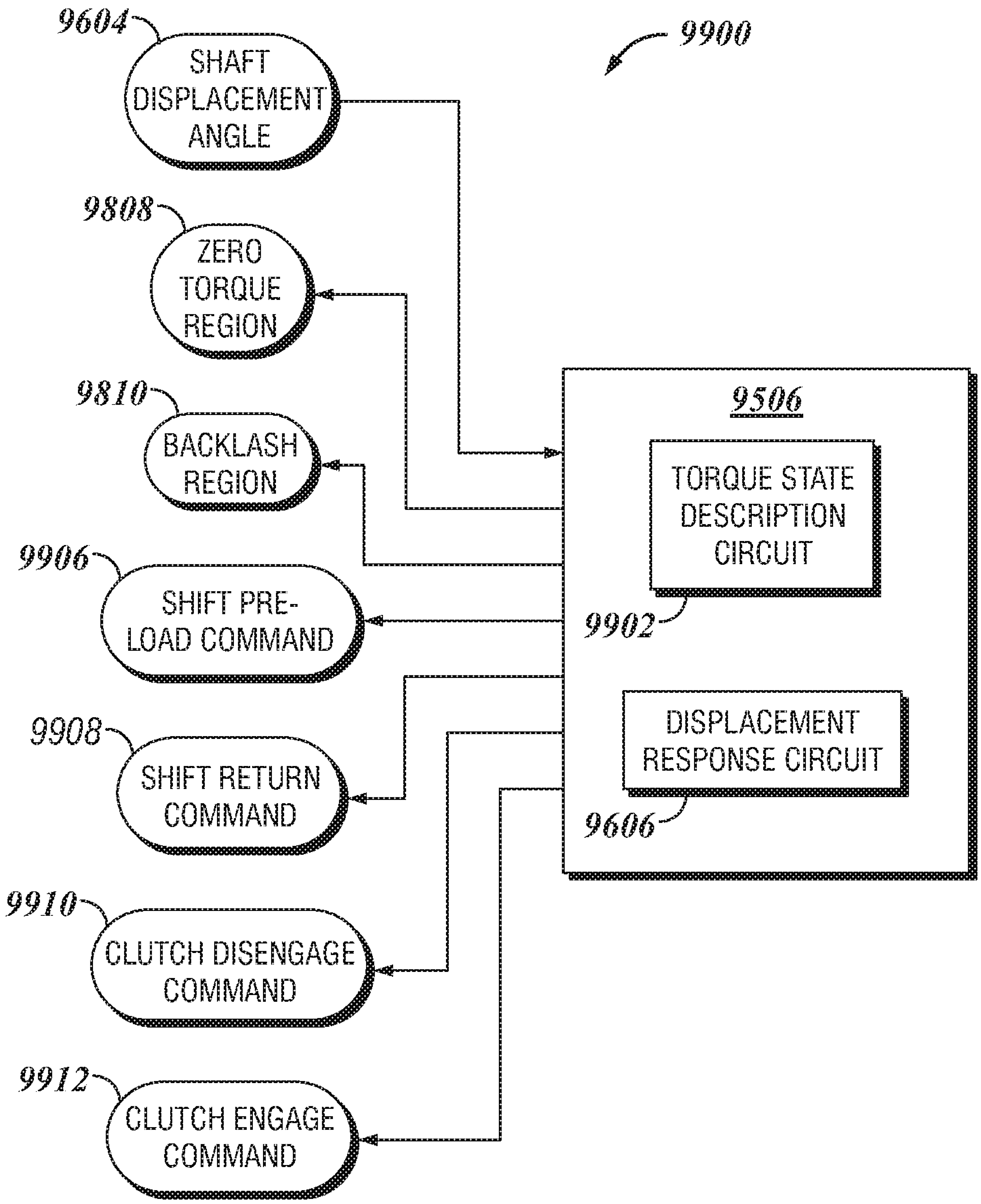
9900
9604
SHAFT DISPLACEMENT ANGLE
9808
ZERO TORQUE REGION
9810
BACKLASH REGION
9906
SHIFT PRE-LOAD COMMAND
9908
SHIFT RETURN COMMAND
9910
CLUTCH DISENGAGE COMMAND
9912
CLUTCH ENGAGE COMMAND
9506
TORQUE STATE DESCRIPTION CIRCUIT
9902
DISPLACEMENT RESPONSE CIRCUIT
9606

FIG. 63

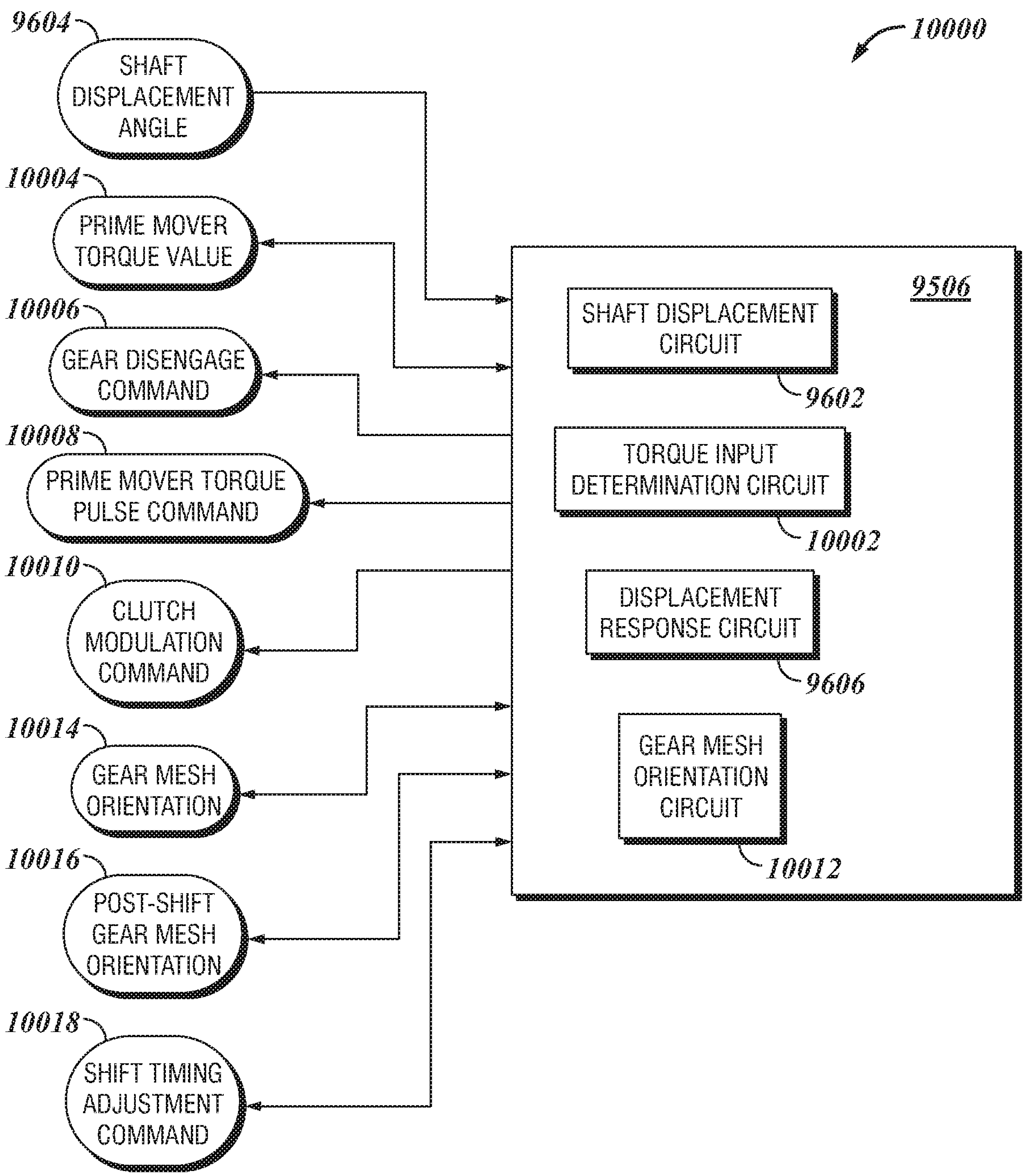
10000
9604
SHAFT DISPLACEMENT ANGLE
10004
PRIME MOVER TORQUE VALUE
10006
GEAR DISENGAGE COMMAND
10008
PRIME MOVER TORQUE PULSE COMMAND
10010
CLUTCH MODULATION COMMAND
10014
GEAR MESH ORIENTATION
10016
POST-SHIFT GEAR MESH ORIENTATION
10018
SHIFT TIMING ADJUSTMENT COMMAND
9506
SHAFT DISPLACEMENT CIRCUIT
9602
TORQUE INPUT DETERMINATION CIRCUIT
10002
DISPLACEMENT RESPONSE CIRCUIT
9606
GEAR MESH ORIENTATION CIRCUIT
10012

FIG. 64

SYSTEM, METHOD, AND APPARATUS FOR OPERATING A HIGH EFFICIENCY, HIGH OUTPUT TRANSMISSION

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to the following U.S. Provisional patent applications: Ser. No. 62/438,201, filed Dec. 22, 2016, entitled "HIGH EFFICIENCY, HIGH OUTPUT TRANSMISSION"; and Ser. No. 62/465,024, filed Feb. 28, 2017, entitled "UTILIZATION OF A SHAFT DISPLACEMENT ANGLE IN A HIGH EFFICIENCY, HIGH OUTPUT TRANSMISSION". All of the applications listed above are hereby incorporated by reference in their entirety.

BACKGROUND

Field

Without limitation to a particular field of technology, the present disclosure is directed to transmissions configured for coupling to a prime mover, and more particularly to transmissions for vehicle applications, including truck applications.

Transmissions serve a critical function in translating power provided by a prime mover to a final load. The transmission serves to provide speed ratio changing between the prime mover output (e.g. a rotating shaft) and a load driving input (e.g. a rotating shaft coupled to wheels, a pump, or other device responsive to the driving shaft). The ability to provide selectable speed ratios allows the transmission to amplify torque, keep the prime mover and load speeds within ranges desired for those devices, and to selectively disconnect the prime mover from the load at certain operating conditions.

Transmissions are subjected to a number of conflicting constraints and operating requirements. For example, the transmission must be able to provide the desired range of torque multiplication while still handling the input torque requirements of the system. Additionally, from the view of the overall system, the transmission represents an overhead device—the space occupied by the transmission, the weight, and interface requirements of the transmission are all overhead aspects to the designer of the system. Transmission systems are highly complex, and they take a long time to design, integrate, and test; accordingly, the transmission is also often required to meet the expectations of the system integrator relative to previous or historical transmissions. For example, a reduction of the space occupied by a transmission may be desirable in the long run, but for a given system design it may be more desirable that an occupied space be identical to a previous generation transmission, or as close as possible.

Previously known transmission systems suffer from one or more drawbacks within a system as described following. To manage noise, robustness, and structural integrity concerns, previously known high output transmission systems use steel for the housing of the transmission. Additionally, previously known high output transmissions utilize a large countershaft with high strength spur gears to manage the high loads through the transmission. Previously known gear sets have relatively few design degrees of freedom, meaning that any shortcomings in the design need to be taken up in the surrounding transmission elements. For example, thrust loads through the transmission, noise generated by gears,

and installation issues such as complex gear timing issues, require a robust and potentially overdesigned system in the housing, bearings, and/or installation procedures. Previously known high output transmissions, such as for trucks, typically include multiple interfaces to the surrounding system (e.g. electrical, air, hydraulic, and/or coolant), each one requiring expense of design and integration, and each introducing a failure point into the system. Previously known high output transmissions include a cooler to protect the parts and fluids of the transmission from overheating in response to the heat generated in the transmission. Previously known high output transmissions utilize concentric clutches which require complex actuation and service. Accordingly, there remains a need for improvements in the design of high output transmissions, particularly truck transmissions.

SUMMARY

An example transmission includes an input shaft configured to couple to a prime mover, a countershaft having a first number of gears mounted thereon, a main shaft having a second number of gears mounted thereon, a shifting actuator that selectively couples the input shaft to the main shaft by rotatably coupling at least one of the first number of gears to the countershaft and/or coupling the second number of gears to the main shaft, where the shifting actuator is mounted on an exterior wall of a housing, and where the countershaft and the main shaft are at least partially positioned within the housing.

Certain further embodiments of an example transmission are described following. An example transmission includes an integrated actuator housing, where the shifting actuator is operationally coupled to the integrated actuator housing, and where the shifting actuator is accessible by removing the integrated actuator housing; a number of shifting actuators operationally coupled to the integrated housing actuator, where the number of shifting actuators are accessible by removing the integrated actuator housing; where the shifting actuator is mechanically coupled to the integrated actuator housing; and/or where a number of shifting actuators are mechanically coupled to the integrated housing actuator. An example transmission includes a clutch actuator accessible by removing the integrated actuator housing; where the clutch actuator is a linear clutch actuator; the example transmission further including a clutch actuator housing; where the linear clutch actuator is positioned at least partially within the clutch actuator housing; and where the clutch actuator housing coupled to the integrated actuator housing and/or included as a portion of the integrated actuator housing; where the integrated housing actuator includes a single external power access, and/or where the single external power access includes an air supply port. An example transmission includes the integrated actuator housing defining power connections between actuators operationally coupled to the integrated actuator housing; where the integrated actuator housing is mounted on a vertically upper side of the transmission; where the shifting actuators are accessible without decoupling the input shaft from the prime mover; where the integrated actuator housing is accessible without decoupling the input shaft from the prime mover; where the linear clutch actuator is pneumatically activated; where the linear clutch actuator has a first extended position and a second retracted position, and where the linear clutch actuator includes a near zero dead air volume in the second retracted position; where the dead air volume includes an air volume on a supply side of the linear

clutch actuator that is present when the linear clutch actuator is retracted; and/or where the linear clutch actuator has a first extended position and a second retracted position, and where the second retracted position is stable over a selected service life of a clutch operationally coupled to the linear clutch actuator.

An example transmission includes a driveline having an input shaft, a main shaft, and a countershaft that selectively couples the input shaft to the main shaft, a housing element with at least part of the driveline positioned in the housing, where the housing element includes aluminum, and where the transmission is a high output transmission. Certain further embodiments of an example transmission are described following. An example transmission includes the transmission having no cooler; where the countershaft selectively couples the input shaft to the main shaft using helical gear meshes, and/or where the helical gear meshes provide thrust management; where the housing does not takes thrust loads from the driveline; where the helical gear meshes further provide thrust management such that a bearing at a low speed differential position in the transmission takes thrust loads from the driveline; and/or where the bearing taking thrust at a low speed differential position is a bearing operationally coupled to the input shaft and the main shaft. An example transmission further includes a planetary gear assembly coupled to a second main shaft, where the planetary gear assembly includes helical gears; where the planetary gear assembly provides a thrust load in response to power transfer through the planetary gear assembly; where the first main shaft is rotationally coupled to the second main shaft; where the transmission does not include taper bearings in the driveline; where the countershaft is a high speed countershaft; where the transmission includes a number of high speed countershafts; and where a first gear ratio between the input shaft and the countershaft, a second gear ratio between the countershaft and the main shaft, have a ratio where the second gear ratio is greater than the first gear ratio by at least 1.25:1, at least 1.5:1, at least 1.75:1, at least 2:1, at least 2.25:1, at least 2.5:1, at least 2.75:1, at least 3:1, at least 3.25:1, at least 3.5:1, at least 3.75:1, at least 4:1, at least 4.25:1, at least 4.5:1, at least 4.75:1, at least 5:1, at least 6:1, at least 7:1, at least 8:1, at least 9:1, and/or at least 10:1.

An example transmission includes a driveline having an input shaft, a main shaft, and a countershaft that selectively couples the input shaft to the main shaft, and a low loss lubrication system. Certain further embodiments of an example transmission are described following. An example transmission includes the low loss lubrication system having a dry sump; the low loss lubrication system having a lubrication pump assembly positioned within the transmission; the low loss lubrication system including a lubrication pump rotationally coupled to the countershaft, and/or where the countershaft is a high speed countershaft; a lubrication sleeve positioned at least partially within the main shaft, and/or where the lubrication sleeve is an unsealed lubrication sleeve.

An example transmission includes a driveline having an input shaft, a main shaft, and a countershaft that selectively couples the input shaft to the main shaft, a countershaft that includes a number of gears mounted thereon, and a power take-off (PTO) access positioned in proximity to at least one of the number of gears. Certain further embodiments of an example transmission are described following. An example transmission includes the PTO access being an 8-bolt PTO access; the transmission including an aluminum housing; the transmission further having a first end engaging a prime mover and a second end having an output shaft, and a second PTO access positioned at the second end; where the transmission is an automated manual transmission; and/or a second countershaft, where the PTO access is positioned in proximity to the countershaft or the second countershaft.

An example transmission includes an input shaft configured to couple to a prime mover, a countershaft having a first number of gears mounted thereon, a main shaft having a second number of gears mounted thereon, where the first number of gears and the second number of gears are helical gears, and where the transmission is a high output transmission. Certain further embodiment of an example transmission are described following. An example transmission includes an aluminum housing, where the main shaft and the countershaft are at least partially positioned in the housing; a bearing pressed into the housing, where the helical gears manage thrust loads such that the bearing pressed into the housing does not experience thrust loads; where the first number of gears and second number of gears include a shortened tooth height and/or a flattened top geometry.

An example clutch assembly includes a clutch disc configured to engage a prime mover, a pressure plate having a clutch biasing element, where the clutch engagement member couples to a clutch actuation element at an engagement position, and where a clutch adjustment member maintains a consistent engagement position as a face of the clutch disc experiences wear. Certain further embodiments of an example clutch assembly are described following. An example clutch assembly includes the clutch adjustment member having a cam ring operable to rotate in response to clutch disc wear; a pressure plate defining the clutch biasing element and the clutch adjustment member; the pressure plate further defining access holes for the clutch adjustment member; the clutch assembly further including an anti-rotation member operationally coupled to the clutch adjustment member to enforce one-way movement of the clutch adjustment member; and/or the pressure plate further defining at least one access channel for the anti-rotation member.

Architectures for high output, high efficiency, low noise and otherwise improved automated transmissions are disclosed herein, including methods, systems, and components for automated truck transmissions. Such methods and systems may include, among other things, a pair of high speed, twin countershafts. Architectures for 18-speed (including 3×3×2 architectures with three gear boxes) and 12-speed (including 3×2×2 architectures with three gear boxes) are disclosed. In embodiments, such methods and systems include methods and systems for thrust load cancellation, including cancellation of loads across a helical or sun gear used in at least one gear box of the transmission. In embodiments, enclosures, such as for the clutch and various gears are configured such that enclosure bearings are isolated from thrust loads, among other things allowing for use of lightweight materials, such as die cast aluminum, for various components of the transmission, without compromising performance or durability. A low-loss lubrication system may be provided for various components of the transmission.

In embodiments, clutch actuation (including for a linear clutch actuator that may actuate movement of a use a horseshoe, or off-axis, clutch actuator) and gear shift actuation for an automated truck transmission are handled through an integrated electrical and mechanical assembly, which may be mounted in a mounted transmission module (MTM) on the transmission, and which may use a common, integrated air supply for pneumatic actuation of clutch and gear systems, optionally employing integrated conduits, rather than hoses, to reduce the free volume of air and thereby enhance the efficiency, reliability and performance of the gear and clutch actuation systems. The MTM may include a linear clutch actuator, position sensor and valve banks for gear and clutch actuation.

Gear systems, including substantially circular gears and helical gears, may be optimized to reduce noise and provide smooth shifting. Circular gears may have substantially flat teeth, may be wormwheel-ground to provide smooth surfaces, and may be provided with profiles optimized to provide optimized sliding velocity of engagement during gear shifts. The transmission may power power-take off (PTO) interfaces, optionally including multiple PTO interfaces.

An example system includes a transmission having an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing a torque output to a driveline. The system further includes a controller, the controller having a shaft displacement circuit that interprets a shaft displacement angle, where the shaft displacement angle includes an angle value representative of a rotational displacement difference between at least two shafts of the transmission. The controller further includes a displacement response circuit that performs a transmission operation in response to the shaft displacement angle.

Certain further aspects of the system are described following, any one or more of which may be included in certain embodiments. An example system includes the transmission further including a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end, and where the shaft displacement angle includes an input angle, where the input angle includes an angle value representative of a rotational displacement difference between the input shaft and the countershaft; the controller further comprising a shift state description circuit that determines that a synchronizer is unblocked in response to the input angle, and the displacement response circuit further providing a shift engagement command in response to the determining the synchronizer is unblocked, and the system further including a shift actuator responsive to the shift engagement command; where the shift actuation circuit further provides a shift opposition command in response to the determining the synchronizer is unblocked, and where the shift actuator is further responsive to the shift opposition command; where the shift engagement command includes an increased actuation pressure relative to a decreased actuation pressure applied during a synchronization operation; where the shift opposition command includes an increased opposition pressure to a movement of a shift actuator relative to a synchronization opposition pressure, the synchronization opposition pressure including an opposition pressure during a synchronization operation and/or a synchronizer approach operation; where the increased opposition pressure includes an amount of opposition pressure selected to reduce a final engagement velocity of the shift actuator; and/or where the shift state description circuit further determines the synchronizer is unblocked in response to a rate of change of the input angle; where the shift state description circuit further determines the synchronizer is unblocked in response to a rate of change of the input angle transitioning from a first rate of change to a second rate of change, and where the first rate of change is associated with a synching position of the shift actuator, and wherein the second rate of change is associated with synchronizer unblock position of the shift actuator. An example system further includes a gear mesh between a first gear on the countershaft and a second gear on the input shaft being a forward-most gear mesh in the transmission.

Certain further aspects of an example system are described following, any one or more of which may be included in certain embodiments. An example system includes the transmission further having a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end, where the countershaft is selectively coupled to the output shaft at the second end via a main shaft selectively coupled to the output shaft, and where the shaft displacement angle includes an angle such as: an input angle including an angle value representative of a rotational displacement difference between the input shaft and the countershaft, a main box angle including a rotational displacement difference between the countershaft and the output shaft, and/or an output angle including a rotational displacement difference between the input shaft and the output shaft; the controller including a zero torque determination circuit that determines the transmission is operating in a zero torque region in response to the shaft displacement angle including a difference value below a zero torque threshold value; the controller further including a zero torque determination circuit that determines that the transmission is operating in a zero torque region in response to a difference value of the shaft displacement angle exhibiting a change in sign; the controller further including a backlash determination circuit that determines that the transmission is in a backlash region in response to the shaft displacement angle including a difference value below a zero torque threshold value; and/or the controller further including a backlash determination circuit that determines that the transmission is in a backlash region in response to a difference value of the shaft displacement angle exhibiting a change in sign.

Certain further aspects of the system are described following, any one or more of which may be included in certain embodiments. An example system including the controller further having a torque state description circuit that determines, in response to the shaft displacement angle, that the transmission is in one of: a zero torque region and/or an imminent zero torque region, and the displacement response circuit further providing a shift pre-load command in response to the determining the transmission is in one of the zero torque region or the imminent zero torque region, and a shift actuator responsive to the shift pre-load command; where the shift pre-load command includes a command to pre-load an actuator volume, wherein the pre-loaded actuator volume urges the shift actuator to a neutral position; where the shift actuator corresponds to a gear mesh that is not being shifted during a shift event; where a second gear mesh that is being shifted during the shift event is positioned forward in the transmission relative to the gear mesh that is not being shifted; and/or where the displacement response circuit further provides a shift return command, and where the shift actuator is responsive to the shift return command to return the shift actuator to an engaged position.

Certain further aspects of an example system are disclosed following, any one or more of which may be included in certain embodiments. An example system includes the controller further having a torque state description circuit that determines, in response to the shaft displacement angle, that the transmission is in one of: a backlash region and/or an imminent backlash region, and the displacement response circuit further providing a shift pre-load command in response to the determining the transmission is in one of the backlash region or the imminent backlash region, and a shift actuator responsive to the shift pre-load command; where the shift pre-load command includes a command to pre-load an actuator volume, where the pre-loaded actuator volume urges the shift actuator to a neutral position; where the shift actuator to a gear mesh that is not being shifted during a shift event; where a second gear mesh that is being shifted during the shift event is positioned forward in the transmission relative to the gear mesh that is not being shifted; and/or where the displacement response circuit further provides a shift return command, where the shift actuator is responsive to the shift return command to return the shift actuator to an engaged position, and a shift actuator responsive to the shift engagement command.

Certain further aspects of an example system are disclosed following, any one or more of which may be included in certain aspects. An example system includes a clutch that selectively decouples a prime mover from the input shaft of the transmission, a progressive actuator operationally coupled to the clutch, where a position of the progressive actuator corresponds to a position of the clutch, where the controller further includes a torque state description circuit that determines, in response to the shaft displacement angle, that the transmission is in one of: a backlash region and/or an imminent backlash region, a displacement response circuit that further provides a clutch disengage command in response to the determining the transmission is in one of the backlash region or the imminent backlash region, and where the progressive actuator is responsive to the clutch disengage command; where the clutch disengage command includes a command to perform one of disengaging the clutch and slipping the clutch; and/or where the displacement response circuit further provides a clutch engage command, and where the progressive actuator is responsive to the clutch engage command to return the clutch to a locked up position.

Certain further aspects of an example system are disclosed following, any one or more of which may be included in certain aspects. An example system further includes a clutch that selectively decouples a prime mover from the input shaft of the transmission, a progressive actuator operationally coupled to the clutch, where a position of the progressive actuator corresponds to a position of the clutch, and where the controller further includes a torque state description circuit that determines, in response to the shaft displacement angle, that the transmission is in one of: a zero torque region and/or an imminent zero torque region, the displacement response circuit further providing a clutch disengage command in response to the determining the transmission is in one of the zero torque region or the imminent zero torque region, and where the progressive actuator is responsive to the clutch disengage command; where the clutch disengage command includes a command to perform one of disengaging the clutch and slipping the clutch; and/or where the displacement response circuit further provides a clutch engage command, and where the progressive actuator is responsive to the clutch engage command to return the clutch to a locked up position.

Certain further aspects of an example system are disclosed following, any one or more of which may be included in certain aspects. An example system further includes a transmission having an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing a torque output to a driveline, a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end, and where the countershaft is selectively coupled to the output shaft at the second end via a main shaft selectively coupled to the output shaft, and a controller including: a shaft displacement circuit that interprets a shaft displacement angle, the shaft displacement angle including an angle value representative of a rotational displacement difference between at least two shafts of the transmission, and where the shaft displacement angle includes at least one angle such as: an input angle including an angle value representative of a rotational displacement difference between the input shaft and the countershaft, a main box angle including a rotational displacement difference between the countershaft and the output shaft, and an output angle including a rotational displacement difference between the input shaft and the output shaft, and a torque input determination circuit that determines a prime mover torque value in response to the shaft displacement angle; where the torque input determination circuit further determines when a prime mover torque value is zero; where the controller further includes a displacement response circuit structured to provide a gear disengage command in response to the prime mover torque value, and where the system further comprises a shift actuator responsive to the gear disengage command; and/or where the controller further includes a displacement response circuit that provides, in response to the prime mover torque value, a prime mover torque pulse command and/or a clutch modulation command.

An example system includes a transmission having an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing a torque output to a driveline, a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end, and where the countershaft is selectively coupled to the output shaft at the second end via a main shaft selectively coupled to the output shaft, the system further including a controller having a shaft displacement circuit that interprets a shaft displacement angle, the shaft displacement angle including an angle value representative of a rotational displacement difference between at least two shafts of the transmission, and where the shaft displacement angle includes at least one angle such as: an input angle including an angle value representative of a rotational displacement difference between the input shaft and the countershaft, a main box angle including a rotational displacement difference between the countershaft and the output shaft, and an output angle including a rotational displacement difference between the input shaft and the output shaft, the system further including a gear mesh orientation circuit that determines a gear mesh orientation in response to the shaft displacement angle.

Certain further embodiments of the system where the gear mesh orientation includes one of a drive side and a coast side, where the controller further includes a displacement response circuit that determines that the gear mesh orientation is opposite a post-shift gear mesh orientation for an impending shift event; and/or where the displacement response circuit, in response to the gear mesh orientation being opposite the post-shift gear mesh orientation, provides at least one command such as: a prime mover torque pulse command, a clutch command, and a shift timing adjustment command.

These and other systems, methods, objects, features, and advantages of the present disclosure will be apparent to those skilled in the art from the following detailed description of the preferred embodiment and the drawings.

All documents mentioned herein are hereby incorporated in their entirety by reference. References to items in the singular should be understood to include items in the plural, and vice versa, unless explicitly stated otherwise or clear from the text. Grammatical conjunctions are intended to express any and all disjunctive and conjunctive combinations of conjoined clauses, sentences, words, and the like, unless otherwise stated or clear from the context.

BRIEF DESCRIPTION OF THE FIGURES

The disclosure and the following detailed description of certain embodiments thereof may be understood by reference to the following figures:

FIG. **1** depicts an example transmission.

FIG. **2** depicts an example transmission.

FIG. **3** depicts an example transmission.

FIG. **4** depicts an example transmission.

FIG. **5** depicts an example transmission.

FIG. **6** depicts an example transmission.

FIG. **7** depicts an example transmission.

FIG. **8** depicts a cutaway view of an example transmission.

FIG. **9** depicts a cutaway view of an example transmission.

FIG. **10** depicts a cutaway view of an example transmission.

FIG. **11** depicts an exploded view of an example transmission.

FIG. **12** depicts an exploded view of an example friction brake.

FIG. **13** depicts an example integrated actuation assembly.

FIG. **14** depicts an example transmission control module.

FIG. **15** depicts an example integrated actuation assembly.

FIG. **16** depicts an example lubrication pump assembly.

FIG. **17** depicts an exploded view of an example lubrication pump assembly.

FIG. **18** depicts example bushing lubrication tubes in the context of an example transmission.

FIG. **19** depicts an example bushing lubrication tube.

FIG. **20** depicts an example bushing lubrication tube.

FIG. **21** depicts an example bushing lubrication tube.

FIG. **22** depicts an example bushing lubrication tube.

FIG. **23** depicts a cutaway view of an example driveline assembly.

FIG. **24** depicts an example driveline assembly.

FIG. **25** depicts a cutaway view of an example driveline assembly.

FIG. **26** depicts a cutaway view of an example input shaft assembly.

FIG. **27** depicts a cutaway view of an example actuator assembly.

FIG. **28** depicts a cutaway view of an example input shaft end.

FIG. **29** depicts a cutaway view of an example main shaft portion.

FIG. **30** depicts a cutaway view of an example countershaft.

FIG. **31** depicts a detail of an example roller bearing.

FIG. **32** depicts a detail of an example roller bearing.

FIG. **33** depicts a cutaway view of an example countershaft.

FIG. **34** depicts a cutaway of an example planetary gear assembly.

FIG. **35** depicts a detail view of an example sliding clutch.

FIG. **36** depicts a detail view of an example output synchronization assembly.

FIG. **37** depicts an example output shaft assembly portion.

FIG. **38** depicts an example planetary gear assembly portion.

FIG. **39** depicts an example shift actuator in proximity to a sliding clutch.

FIG. **40** depicts an example transmission.

FIG. **41** depicts an example exploded clutch assembly.

FIG. **42** depicts an example exploded clutch assembly.

FIG. **43** depicts an example pressure plate assembly.

FIG. **44** depicts an example pressure plate assembly.

FIG. **45** is a schematic flow diagram of a service event.

FIG. **46** is a schematic flow diagram of a service event.

FIG. **47** depicts an example clutch housing.

FIG. **48** depicts an example clutch housing.

FIG. **49** depicts an example rear housing.

FIG. **50** depicts an example rear housing.

FIG. **51** depicts an example rear housing.

FIG. **52** depicts an example lubrication pump assembly.

FIG. **53** depicts an example lubrication pump assembly.

FIG. **54** depicts an example main housing.

FIG. **55** depicts an example main housing.

FIG. **56** depicts an example main housing.

FIG. **57** depicts an example main housing.

FIG. **58** depicts an example main housing.

FIG. **59** is a schematic representation of a transmission having a controller.

FIG. **60** is a schematic diagram of a controller for a transmission.

FIG. **61** is a schematic diagram of a controller for a transmission.

FIG. **62** is a schematic diagram of a controller for a transmission.

FIG. **63** is a schematic diagram of a controller for a transmission.

FIG. **64** is a schematic diagram of a controller for a transmission.

DETAILED DESCRIPTION

Referencing FIG. **1**, an example transmission **100** having one or more aspects of the present disclosure is depicted. The example transmission **100** includes a main housing **102**, the main housing **102** defines the outer shape of portions of the transmission **100** and in certain embodiments the main housing **102** includes one or more components made of aluminum. The example main housing **102** is coupled to a clutch housing **104**, wherein the clutch housing **104** includes or is operationally coupled to a clutch **106**. The example transmission **100** further includes a rear housing **108**. The rear housing **108** provides aspects of the transmission **100** enclosure at the rear, including in certain embodiments a planetary or helical gear set disposed within the rear housing **108**, having structural engagement with an output shaft assembly **110**.

The example transmission **100** includes an integrated actuator housing **112** coupled to the main housing **102**. The integrated actuator housing **112** in the example of FIG. **1** is coupled to the top of the transmission **100**, and the main housing **102** includes an opening (not shown) at the position where the integrated actuator housing **112** coupled to the main housing **102**. In the example transmission **100** the opening in the main housing **102** provides access for actuators operationally coupled to the integrated actuator housing **112**, including for example a clutch actuator and/or one or more gear shifting actuators. Example transmission **100** further includes a transmission control module **114** (TCM), where the example TCM **114** couples directly to the integrated actuator housing **112**.

The arrangement of the aspects of the transmission **100** depicted in FIG. **1** is an example and nonlimiting arrangement. Other arrangements of various aspects are contemplated herein, although in certain embodiments one or more of the arrangements depicted in FIG. **1** may be advantageous as described throughout the present disclosure. Particular arrangements and aspects of the transmission **100** may be included in certain embodiments, including one or more of the aspects arranged as depicted, and one or more of the aspects arranged in a different manner as would be understood to one of skill in the art contemplating a particular application and/or installation.

The description of spatial arrangements in the present disclosure, for example front, rear, top, bottom, above, below, and the like are provided for convenience of description and for clarity in describing the relationship of components. The description of a particular spatial arrangement and/or relationship is nonlimiting to embodiments of a transmission **100** consistent with the present disclosure, in a particular transmission **100** may be arranged in any manner understood in the art. For example, and without limitation, a particular transmission **100** may be installed such that a "rear" position may be facing a front, side, or other direction as installed on a vehicle and/or application. Additionally or alternatively, the transmission **100** may be rotated and or tilted about any axis, for example and without limitation at an azimuthal angle relative to a driveline (e.g. the rotational angle of the clutch **106**), and/or a tilting from front to back such as to accommodate an angled driveline. Accordingly, one or more components may be arranged relatively as described herein, and a component described as above another component may nevertheless be the vertically lower component as installed in a particular vehicle or application. Further, components for certain embodiments may be arranged in a relative manner different than that depicted herein, resulting in a component described as above another component being vertically lower for those certain embodiments or resulting in a component described as to the rear of another being positioned forward of the other, depending on the frame of reference of the observer. For example, an example transmission **100** includes two countershafts (not shown) and a first particular feature engaging an upper countershaft may be described and depicted as above a second particular feature engaging a lower countershaft; it is nevertheless contemplated herein that an arrangement with the first particular feature engaging the lower countershaft in the second particular feature engaging the upper countershaft is consistent with at least certain embodiments of the present disclosure, except where context indicates otherwise.

Referencing FIG. **2**, a transmission **100** is depicted in a top view, wherein the transmission **100** depicted in FIG. **2** is consistent with the transmission **100** depicted in FIG. **1**. In the top view of the transmission **100**, the rear housing **108**, the clutch housing **104**, and the main housing **102** remain visible. Additionally, the integrated actuator housing **112** and TCM **114** are visible at the top of the main housing **102**. The example transmission **100** further includes a clutch actuator housing **202** that provides accommodation for a clutch actuator assembly (not shown in FIG. **2**). Clutch actuator housing **202** is depicted as a portion of the integrated actuator housing **112** and positioned at the top of the transmission **100**. The example clutch actuator housing **202** and clutch actuator assembly, as evidenced by the position of the clutch actuator housing **202**, engages an upper countershaft at the rear side; however, a lubrication pump assembly may engage one or more countershafts at any axial position along the transmission **100**. Further details of an example lubrication pump assembly are described in other portions of the present disclosure.

The example transmission **100** of FIG. **2** further depicts the output shaft assembly **110** at a rear of the transmission, in the example depicted as a standard driveline output shaft assembly **110**; however, any output shaft assembly **110** design for the particular application is contemplated herein. The transmission **100** further depicts an input shaft **204**, in the example the input shaft **204** extends through the clutch **106** on the outside of the transmission **100**, in engages a prime mover shaft, such as tail shaft. An example input shaft **204** includes a spline engagement with a prime mover shaft, although any coupling arrangement understood in the art is contemplated herein.

The example transmission **100** depicted in FIG. **2** includes a single air input line (not shown), which in the example is pneumatically coupled to the integrated actuator housing **112**. In certain embodiments, the transmission **100** includes a clutch actuator and one or more shift actuators, wherein the clutch actuator and the shift actuator(s) are powered by a single or common air input supply line as depicted in the example of FIG. **2**. Additionally or alternatively, each of the actuators may be powered by separate power inputs, and/or alternative power sources, such as, but not limited to, a hydraulic and/or an electric source.

Referencing FIG. **3**, a transmission **100** arranged in a similar orientation to the representation depicted in FIG. **1** is illustrated to more clearly show certain aspects of the transmission **100**. The example transmission **100** includes the integrated actuator housing **112**, wherein an air input port **302** provides pneumatic access for the air input supply to engage the clutch actuator and the shift actuator(s). The example transmission **100** includes only a single power input to operate all actuators, and in further embodiments the single power input is included as an air input port **302**. In embodiments, a single air supply is provided for pneumatic actuation of the clutch actuator (such as a linear clutch actuator (LCA) and each of the gear shift actuators (e.g., actuators for front, main and rear gear boxes). In embodiments, the air supply is handled within the integrated actuator housing via a set of conduits that accept air from the air input supply and deliver the air to power movement of each of the actuators. The conduits may be integrated (e.g., machined, cast, etc.) into the housing/structure of the integrated actuator housing, such that air is delivered without requiring separate hoses or the like, between the air input supply and the respective actuators for clutch and gear movement. Among other benefits, this removes potential points of failure (such as leaky hoses or poor connections to hoses) and allows very precise control (because, among other reasons, the volume of air is smaller and more precisely defined that for a hose-based system). It should be understood that a given integrated actuator housing **112** includes the number and type of power access points for the particular arrangement, such as an electrical and/or hydraulic input, and/or more than one input of a given type, such as pneumatic. Additionally or alternatively, in certain embodiments the transmission **100** includes one or more power inputs positioned in locations distinct from the location of the air input port **302** in the example of FIG. **4**.

The example transmission **100** depicted in FIG. **3** further shows a sensor port **304**. In the example of FIG. **3**, sensor port **304** couples a controller on the TCM **114** to a speed sensor on the output shaft assembly **110** of the transmission **100**. Referencing FIG. **4**, a sensor coupler **404** operationally couples a sensor (e.g. a speed sensor of any type, such as a hall effect, variable reluctance, tachograph, or the like) to the sensor connector **304**, for example to provide an output shaft speed value to the TCM **114**. Additionally, the transmission **100** includes an oil pressure sensor **406**. In embodiments, a given transmission **100** may include any number of sensors of any type desired, including having no speed sensor and/or other sensors. In certain embodiments, the type and source of information may vary with the control features and diagnostics present in the system. Additionally or alternatively, any given sensed value may instead be determined from other values known in the system (e.g. a virtual sensor, model, or other construction or derivation of a given value from other sensors or other known information), and/or any given sensed value may be determined from a datalink communication or alternate source rather than or in addition to a direct sensor coupled to a controller. The controller may be in communication with any sensor and/or actuator anywhere on the transmission **100** and/or within a system including or integrated with the transmission **100**, such as a driveline, vehicle, or other application, as well as with remote systems, such as through one or more communications networks, such as Bluetooth™, cellular, WiFi, or the like, including to remote systems deployed in the cloud, such as for telematics and similar applications, among others.

The example transmission **100** includes a pair of electrical connectors **402** (reference FIG. **4**), depicted as two standard 20-pin connectors in the example depicted in FIG. **4**, although any electrical interface may be utilized. An example TCM **114** includes an electrical connection between the TCM **114** and the integrated actuator housing **112**, for example wherein the TCM **114** plugs into the integrated actuator housing **112** providing electrical datalink communication (e.g. between a controller present on the integrated actuator and the controller on the TCM **114**—not shown) and/or direct actuator control of actuators in the integrated actuator housing **112**. In certain embodiments, a single controller may be present which performs all operations on the transmission **100**, and/or the functions of the transmission **100** may be divided among one or more controllers distinct from the controller arrangement depicted in FIG. **4**. For example and without limitation, a vehicle controller, application controller, engine controller, or another controller present in the transmission **100** or overall system may include one or more functions of the transmission **100**.

The example transmission **100** further includes a clutch **106**. The example clutch **106** includes a clutch face **306** and one or more torsional springs **308**. Example clutch face **306** includes a number of frictional plates **310**, and the clutch face **306** presses against an opposing face from a prime mover (not shown), for example a flywheel of the engine. The torsional springs **308** of the example clutch face **306** provide rotational damping of the clutch **106** to transient forces while maintaining steady state alignment of the clutch **106**. The clutch face **306** may alternatively be any type of clutch face understood in the art, including for example a single frictional surface rather than frictional plates **310**. In the example clutch face **306**, the frictional plates **310** are included as a portion of the clutch face **306**. The divisions between the clutch plates are provided as grooved divisions of the clutch face **306** base material to provide desired performance (e.g. frictional performance, debris management, and/or heat transfer functions), but any clutch face **306** configuration including alternate groove patterns and/or no presence of grooves is contemplated herein. The material of the example clutch face **306** may be any material understood in the art, including at least a ceramic material and/or organic clutch material. In embodiments, as depicted in more detail below, the clutch **106** may be positioned off-axis relative to the prime mover, is disposed around (such as via a yoke, horseshoe or similar configuration) the prime mover (e.g., a shaft), is pivotably anchored on one side (such as by a hinge or similar mechanism that allows it to pivot in the desired direction of movement of the clutch **106**, and is actuated by the linear clutch actuator (which may also be positioned off-axis, opposite the anchoring side, so that linear actuation causes the clutch to pivot in the desired direction).

Referencing FIG. **4**, an example transmission **100** is depicted from a side view, with the output shaft assembly **110** positioned at the left side of FIG. **4**, in the clutch housing **104** positioned at the right side of FIG. **4**. The transmission **100** depicted in FIG. **4** includes numerous features that may be present in certain embodiments. For example, numerous fins **408** and/or projections are present that provide selected stress characteristics, management of stress in the housing, and or selected heat transfer characteristics. The example transmission **100** further depicts a power take off device (PTO) interface **410** that allows access for a PTO installation to engage the transmission on a lower side. Additionally or alternatively the transmission **100** may include a second PTO interface on the rear of the transmission (not shown), for example to allow PTO engagement at the rear of the transmission **100**. A rear PTO engagement may be provided with a hole (which may be plugged for a non-PTO installation) or other access facility, where the PTO may be engaged, for example, with a quill shaft engaging one of the countershafts of the transmission **100** on a first end and providing an engagement surface, such as a spline, on a second end extending from the transmission **100**. The example transmission of FIG. **4** additionally depicts a number of lift points **412**, which are optionally present, and which may be arranged as shown or in any other arrangement or position.

Referencing FIG. **5**, another view of an example transmission **100** is provided depicting a clear view of the clutch actuator housing **202**, the integrated actuator housing **112**, in the TCM **114**. The example transmission **100** further includes a number of couplings **502** between the main housing **102** and a rear housing **108**, and a number of couplings **504** between the main housing **102** and the clutch housing **104**. In certain embodiments the selection of housing elements (**102**, **104**, **108**) that includes the driveline portions of the transmission **100** may be distinct from the selection of housing elements (**102**, **104**, **108**) as depicted in FIG. **5**. For example, certain housing elements may be combined, divided, and/or provided at distinct separation points from those depicted in FIG. **5**. Several considerations that may be included in determining the selection of housing elements include the strength of materials utilized in manufacturing housings, the power throughput of the transmission **100**, the torque (maximum and/or transient) throughput of the transmission **100**, manufacturability considerations (including at least positioning the housing and devices within the housing during manufacture, materials selected for the housing, and/or manufacturing cost and repeatability considerations), and the cost and/or reliability concerns associated with each housing interface (for example the interface **506** between the main housing **102** and the rear housing **108**).

Referencing FIG. **6**, another view of an example transmission **100** is provided depicting a clear view of the PTO interface **410**. The example PTO interface **410** is an 8 bolt interface provided on a lower side of the transmission **100**.

Referencing FIG. **7** a schematic view of a transmission housing **700** is depicted. The housing **700** includes an actuator engagement opening **702** positioned at the top of the transmission. The actuator engagement opening **702** is sized to accommodate attachment of the integrated actuator housing **112**, and to allow actuation elements to be positioned into the transmission **100**. The position, size, shape, and other elements of an actuator engagement opening **702**, where present, may be selected according to the particular features of actuators for the system. The example transmission **100**, actuator engagement opening **702**, and integrated actuator housing **112**, are readily accessible with access to the top of the transmission **100**, and can be installed, serviced, maintained, or otherwise accessed or manipulated without removal of the transmission **100** from the application or vehicle, and/or without disassembly of the transmission **100**. The example housing **700** further includes a clutch actuator engagement opening **704**, sized to accommodate attachment of the clutch housing portion of the integrated actuator housing **112**, and to allow the clutch actuator to be positioned into the transmission **100**. In the example housing **700**, shift actuators (not shown) are positioned into the transmission **100** through the actuator engagement opening **702**, and a clutch actuator is positioned into the transmission **100** through the clutch actuator engagement opening **704**, and it can be seen that a single step installation of the integrated actuator housing **112** provides an insulation of all primary actuators for the transmission **100**, as well as providing a convenient single location for access to all primary actuators.

Referencing FIG. **8**, an example transmission **100** is depicted schematically in a cutaway view. The cutaway plane in the example of FIG. **8** is a vertical plane through the transmission **100**. The example transmission **100** is capable of providing power throughput from a prime mover interfacing with the clutch **106** to the input shaft **204**, from the input shaft **204** to a first main shaft portion **804**, to a second main shaft portion **806** operationally coupled to the first main shaft portion **804**, and from the second main shaft portion **806** to the output shaft assembly **110**. Example transmission **100** is operable to adjust torque multiplication ratios throughout the transmission, to engage and disengage the clutch **106** from the prime mover (not shown), and/or to position the transmission **100** into a neutral position wherein, even if the clutch **106** is engaged to the prime mover, torque is not transmitted from the clutch **106** to the output shaft assembly **110**.

With further reference to FIG. **8**, a clutch engagement yoke **808** is depicted in a first position **808**A consistent with, in certain embodiments, the clutch **106** being engaged with the prime mover (i.e. the clutch **106** in a forward position). For purposes of clarity of the description, the clutch engagement yoke **808** is simultaneously depicted in a second position **808**B consistent with, in certain embodiments, the clutch **106** being disengaged with the prime mover (i.e. the clutch **106** in a withdrawn position). The example clutch engagement yoke **808** is operationally coupled at a first end to a clutch actuator, which in the example of FIG. **8** engages the clutch engagement yoke at the upper end of the clutch engagement yoke **808**. The example clutch engagement yoke **808** is fixed at a second end, providing a pivot point for the clutch engagement yoke **808** to move between the first position **808**A and the second position **808**B. A clutch engagement yoke **808** of the example in FIG. **8** enables convenient actuation of the clutch **106** with a linear actuator, however in certain embodiments of the present disclosure any type of clutch actuation may be utilized, including a concentric clutch actuator (not shown) and/or another type of linear clutch actuation device.

The example transmission **100** further includes an input shaft gear **810** selectively coupled to the input shaft **204**. The inclusion of the input shaft gear **810**, where present, allows for additional distinct gear ratios provided by the input shaft **204**, for example a gear ratio where torque is transmitted to the input shaft gear **810**, where torque is transmitted directly to the first main shaft portion **804** (e.g. with both the input shaft **204** and the first main shaft portion **804** coupled to a first forward gear **812**). In certain embodiments, the shared first forward gear **812** between the input shaft **204** and the first main shaft portion **804** may be termed a "splitter gear," although any specific naming convention for the first forward gear **812** is not limiting to the present disclosure.

The example transmission **100** further includes a number of gears selectively coupled to the first main shaft portion **804**. In the example of FIG. **8**, the first forward gear **812**, a second forward gear **814**, and third forward gear **816** are depicted, and a first reverse gear **818** is further shown. In the example, the first forward gear **812** is couplable to either of the input shaft **204** and/or the first main shaft portion **804**. When the input shaft **204** is coupled to the first forward gear **812** and the first main shaft portion **804** is not, a gear ratio between the input shaft **204** and the first main shaft portion **804** is provided. When the input shaft **204** is coupled to the first forward gear **812** and the first main shaft portion **804** is also coupled to the first forward gear **812**, the input shaft **204** and first main shaft portion **804** turn at the same angular speed. The number and selection of gears depends upon the desired number of gear ratios from the transmission, and the depicted number of gears is not limiting to the present disclosure.

The example transmission **100** further includes a planetary gear assembly **820** that couples the second main shaft portion **806** to the output shaft assembly **110** through at least two selectable gear ratios between the second main shaft portion **806** and the output shaft assembly **110**. The example transmission **100** further includes at least one countershaft, the countershaft having an aligning gear with each of the gears coupleable to the input shaft **204** in the first main shaft portion **804**. The countershaft(s) thereby selectively transmit power between the input shaft **204** in the first main shaft portion **804**, depending upon which gears are rotationally fixed to the input shaft **204** and/or the first main shaft portion **804**. Further details of the countershaft(s) are described following, for example in the portion of the disclosure referencing FIG. **9**.

It can be seen that the transmission **100** in the example of FIG. **8** provides for up to 12 forward gear ratios (2×3×2) and up to four reverse gear ratios (2×1×2). A particular embodiment may include distinct gear arrangements from those depicted, and/or may not use all available gear ratios. In embodiments, an eighteen speed automatic truck transmission may be provided, such as by providing three forward gears, three main gears, and two planetary gears, referred to herein as a three-by-three-by-two architecture. Similarly, a twelve-speed automatic truck transmission can be provided by providing three forward gears, two main gears, and two planetary gears, or other combinations.

Referencing FIG. **9**, an example transmission **100** is depicted schematically in a cutaway view. The example of FIG. **9** depicts a cutaway through a plane intersecting to twin countershafts **902**, **904**. The example countershafts **902**, **904** are positioned at 180° on each side of the first main shaft portion **804**. In certain embodiments the transmission **100** may include only a single countershaft, and/or more than two countershafts. The positioning and angle of the countershafts **902**, **904** depicted in FIG. **9** is a nonlimiting example, and the countershafts **902**, **904** may be adjusted as desired for the application. Each of the example countershafts **902**, **904** includes a gear layer **906** meshing with a corresponding gear on the input shaft **204** and/or the first main shaft portion **804** respectively. The example transmission **100** includes the gears **906** rotationally fixed to the countershafts **902**, **904**, with the corresponding gears on the input shaft **204** and/or the first main shaft portion **804** being selectively rotationally fixed to the input shaft **204** and/or the first main shaft portion **804**. Additionally or alternatively, gears **906** may be selectively rotationally fixed to the countershafts **902**, **904**, with one or more of the corresponding gears on the input shaft **204** and/or the first main shaft portion **804** being rotationally fixed to the input shaft **204** and/or the first main shaft portion **804**. The descriptions of actuators for shifting presented herein utilize the convention that the gears **906** are rotationally fixed to the countershafts **902**, **904**, and changes to which gears are rotationally fixed or selectively rotationally fixed would lead to corresponding changes in actuation.

Example transmission **100** includes a first actuator **908**, for example a shift fork, that moves (e.g., side to side and/or up or down) under actuation, to selectively rotationally couple the input shaft **204** to one of the countershafts **902**, **904**, or to the first main shaft portion **804**. The first actuator **908** interacts with a gear coupler **910**, and in certain embodiments the gear coupler **910** includes a synchronizing component as understood in the art. The first actuator **908** is further operable to position the gear coupler **910** into an intermediate position wherein the input shaft **204** is rotationally decoupled from both the countershafts **902**, **904** and the first main shaft portion **804**—for example placing the transmission **100** into a neutral operating state. In certain embodiments the first actuator **908** is a portion of, and is controlled by an integrated actuator assembly **1300** (e.g. reference FIG. **13**) positioned within the integrated actuator housing **112**.

Example transmission **100** further includes a second actuator **912** that, under actuation, such as moving side to side and/or up or down, selectively rotationally couples one of the first forward gear **812** and the second forward gear **814** to the first main shaft portion **804**, thereby rotationally coupling the countershafts **902**, **904** to the first main shaft portion **804**. The example transmission **100** further includes a third actuator **914** that, under actuation, selectively rotationally couples one of the third forward gear **816** and the reverse gear **818** to the first main shaft portion **804**, thereby rotationally coupling countershafts **902**, **904** to the first main shaft portion **804**. In certain embodiments, the second actuator **912** in the third actuator **914** are operable to be positioned into an intermediate position wherein the first main shaft portion **804** is rotationally decoupled from both the countershafts **902**, **904**—for example placing the transmission **100** into a neutral operating state. In certain embodiments, at least one of the second actuator **912** and the third actuator **914** are positioned into the intermediate position at any given time, preventing coupling of the countershafts **902**, **904** to the first main shaft portion **804** at two different speed ratios simultaneously. In certain embodiments the second actuator **912** and the third actuator **914** are portions of or are integrated with, and are controlled by, the integrated actuator assembly **1300** positioned within the integrated actuator housing **112**.

In the example transmission **100**, the second actuator **912** interacts with a second gear coupler **916**, and the third actuator **914** interacts with a third gear coupler **918**, where each of the second and third gear couplers **916**, **918** may include a synchronizing component. According to the arrangement depicted in FIG. **9**, the first, second, and third actuators **908**, **912**, **914** are operable to provide a number of distinct forward gear options, reflecting different combinations of gear ratios (e.g., six, twelve, or eighteen gears), and a number (e.g., two) of distinct reverse gear ratios. The planetary gear assembly **820** may include a clutch (such as a sliding clutch **920**) configured to position the planetary gear assembly **820** and provide two distinct ratios between the second main shaft portion **806**, and the output shaft assembly **110**. Therefore, according to the arrangement depicted in FIG. **9**, the transmission **100** is operable to provide twelve distinct forward gear ratios, and four distinct reverse gear ratios. In certain embodiments, one or more of the available gear ratios may not be utilized, and a selection of the number of forward gears, number of reverse gears, and number of actuators may be distinct from the arrangement depicted in FIG. **9**.

The example transmission **100** provides for a direct drive arrangement, for example where the first actuator **908** couples the input shaft **204** to the first main shaft portion **804** (gear coupler **910** to the right in the orientation depicted in FIG. **9**), and where the second actuator **912** couples the first main shaft portion **804** the first forward gear. Direct drive operation transfers power through the planetary gear assembly **820**, with the sliding clutch **920** providing either gear reduction (e.g. sliding clutch **920** positioned to the right in the orientation depicted in FIG. **9**) or full direct drive of the transmission **100** (e.g. sliding clutch **920** positioned to the left in the orientation depicted in FIG. **9**). In certain embodiments, direct drive may be a "highest" gear ratio of the transmission **100**, and/or the transmission may include one or more overdrive gears. The determination of the number of gears, how many gears are forward and/or reverse, and the ratios of each gear, including whether and how many overdrive gears may be present, and how many gear ratio combinations are selectable, are configurable features that depend upon desired response characteristics for a particular application. An example transmission **100** includes the integrated actuator assembly **1300** operably coupled to the sliding clutch **920**, for example with a shift fork (not shown) mounted on a shift rail.

The example transmission **100** depicts the PTO interface **410** positioned in proximity to the lower countershaft **904**. In certain embodiments, the transmission **100** includes a main housing **102** where the main housing **102** is made of aluminum, and/or is a cast component. It will be understood that material constraints and component stress management indicate that certain features of an aluminum housing will be larger, thicker, or otherwise modified relative to a steel housing. For example bolt bosses of the PTO interface **410** can be deeper and project further into the main housing **102** for a PTO interface **410** designed in an aluminum housing relative to a similar installation designed in a steel housing. Cast components, in certain embodiments and depending upon casting process used, impose certain constraints upon component design. For example, for certain casting processes it can be beneficial to constrain a component to have a monotonically increasing outer profile or housing shape. Example transmission **100** includes gear ratio and sizing selections, as well as selection of the PTO interface **410** position, such that a gear of the lower countershaft **904** having a greatest radial extent from a centerline the gear train is positioned in proximity to the PTO interface **410**. An example transmission **100** includes the PTO device accessing the transmission **100** at the PTO interface **410** being powered by the first forward gear **812** (e.g. the splitter gear) through the corresponding countershaft gear.

In certain embodiments, the transmission **100** allows for engagement of a PTO device (not shown) directly with a gear engaging in lower countershaft **904**, without having to use in idler gear or similar mechanical configuration to extend power transfer from the lower countershaft **904**. It can also be seen that the example transmission **100** includes a geometric profile of the gears in the gear train, such that an easily castable main housing **102** can be positioned over the gears after the gear train is assembled, and/or the gear train can be assembled into the main housing **102** in a straightforward manner. Further, it can be seen that the example transmission **100** includes provisioning for bolt bosses of the PTO interface **410**, even where deeper bolt bosses are provided, such as an application having an aluminum main housing **102**.

Example transmission **100** further includes a controllable braking device **922** selectively coupleable to at least one of the countershafts **902**, **904**. In the example depicted in FIG. **9**, the braking device **922** is selectively coupleable to the lower countershaft **904**, however a braking device **922** may be coupleable to either countershaft **902**, **904**, and/or more than one braking device may be present in coupleable to each countershaft present. The braking device **922** provides capability to slow the countershaft and/or driveline, to stop the countershaft and/or driveline, and/or to provide stationary hold capability to the driveline. An example braking device **922** includes a braking device actuator **924** (a pneumatic input in the example of FIG. **9**) which may be controllable pneumatically by an integrated actuator assembly **1300** positioned in the integrated actuator housing **112**. Additionally or alternatively, any other actuating means and controller is contemplated herein, including at least an electrical and/or hydraulically operated actuator, and/or any other driveline braking device, is further contemplated herein. Additionally or alternatively, any other type of braking device may be included within the transmission **100** and/or positioned upstream or downstream of the transmission **100**, for example a hydraulic retarder and/or an electric braking device (not shown), which may be controllable by an actuator in the integrated actuator assembly **1300** positioned in the integrated actuator housing **112**, by the TCM **114**, and/or by another control device in the system (not shown).

The example transmission **100** includes the output shaft assembly **110**. The example output shaft assembly **110** includes an output shaft **926**, wherein the output shaft is rotationally coupled to the planetary gear assembly **820**. The output shaft assembly **110** further includes a driveline adapter **928** coupled to the output shaft **926**, and configured to engage a downstream device (not shown) in the driveline. The driveline adapter **928** may be any type of device known in the art, and the specific depiction of the driveline adapter **928** is nonlimiting. The selection of a driveline adapter **928** will depend in part on the application, the type of downstream device, and other considerations known in the art.

Referencing FIG. **10**, an example transmission **100** is depicted schematically in a cutaway view. The cutaway plane and the example of FIG. **10** is a plane intersecting a clutch actuator **1002** in the driveline (e.g. including the input shaft four, the first and second main shaft portions **804**, **806**, in the output shaft assembly **110**). The depiction in FIG. **10** illustrates the clutch engagement yoke **808** in both the first position **808**A in the second position **808**B. The example transmission **100** includes a linear clutch actuator **1002**, positioned within the clutch actuator housing **202** and extending to the clutch engagement yoke **808**. In the example of FIG. **10**, the clutch actuator **1002** is pneumatically operated and applies a pushing force to the clutch engagement yoke **808**, and returns a retracted position in response to force from the clutch engagement yoke **808**. Example clutch actuator **1002** provides a normally engaged clutch **106**, such that if the clutch actuator **1002** is not actively engaging the clutch engagement yoke **808**, the clutch **106** extends and engages. The example clutch actuator **1002** is a pneumatic, linear clutch actuator (LCA), that pushes to engage, however any type of clutch actuator is contemplated herein, for example and without limitation a pull to engage actuator (e.g. utilizing a catapult or other mechanical arrangement), hydraulic and/or electrical actuation, and/or engaging with a normally engaged or normally disengaged clutch **106**. In certain embodiments, the clutch actuator **1002** includes a near zero dead air volume in the retracted position. Example support features to maintain near zero dead air volume for the clutch actuator **1002** are described as follows. In certain embodiments, the utilization of a linear actuator, the inclusion of a near zero dead air volume, and the positioning of the clutch actuator housing **202** as a part of the integrated actuator housing **112** support various enhancements of one or more of accessibility to the clutch actuator housing **202**, accessibility to the clutch actuator **1002**, improvements to the control and/or repeatability of clutch actuation, reduction of points of failure, and/or diagnosing or determining the precise position of the clutch face **306** (including as the clutch **106** wears over time). In certain embodiments, a near zero dead air volume includes a volume **1004** behind the clutch actuator **1002** on a supply side, wherein the volume **1004** is small enough such that provided air immediately begins putting an actuation force onto the clutch actuator **1002**, and/or such that a consistent initial air volume each times begins a consistent movement on the clutch actuator **1002**. Example air volumes that are near zero include, without limitation, the clutch actuator **1002** positioned against an air feed tube (e.g. as depicted in the example of FIG. **10**), a volume small enough such that clutch actuation begins after application of supply pressure within a selected response time (e.g. 5 msec, 10 msec, 20 msec, 40 msec, 100 msec, and/or 200 msec), and/or a volume less than a specified volume difference behind the clutch actuator **1002** on the feed side between the clutch actuator **1002** in a current rest position and the clutch actuator **1002** in a predetermined rest position (e.g. fully positioned against a stop), where the specified volume is approximately zero, less than 0.1 cc, less than 0.5 cc, and/or less than 1 cc. The provided examples for a near zero volume are illustrative and not limiting. One of skill in the art, having the benefit of the present disclosure and information ordinarily available when contemplating a particular embodiment, can readily determine a near zero volume for a contemplated application. Certain considerations to determine a near zero dead air volume include, without limitation, the pressure and/or rate of supplied actuation air, the desired response time for the clutch actuator **1002**, computing resources available on the TCM **114** or elsewhere in the system, and/or the physical responsiveness of the clutch actuator **1002** to supplied air.

The example transmission **100** depicted in FIG. **10** includes a first ball bearing **1102** positioned in the clutch housing **104** (and/or pressed into the clutch housing **104**) and coupled to the input shaft **204**, a second ball bearing **1104** positioned in the main housing **102** (and/or pressed into the main housing **102**) and coupled to the second main shaft portion **806**, and a third ball bearing **1106** positioned in front of the planetary gear assembly **820** and coupled to the second main shaft portion **806**. Additionally or alternatively, the example transmission **100** includes a fourth ball bearing **1109** positioned at an interface between the rear housing **108** and the output shaft assembly **110** (e.g. pressed into the rear housing **108**), and coupled to the output shaft **926**. An example transmission **100** further includes a release bearing **1118** coupled to the clutch **106** and providing a portion of an assembly between the clutch engagement yoke **808** and a clutch assembly to provide for release of the clutch **106** in response to actuation of the clutch engagement yoke **808**.

Referencing FIG. **11**, certain elements of an example housing assembly **1100** are depicted schematically and in exploded view. The example housing assembly **1100** depicts the clutch housing **104**, the main housing **102**, and the rear housing **108**. Example housing assembly **1100** includes the first ball bearing **1102** positioned in the clutch housing **104** and engaging the input shaft **204**, the second ball bearing **1104** positioned in the main housing **102** and engaging the second main shaft portion **806**, and the fourth ball bearing **1109** positioned in the rear housing **108** and engaging the output shaft **926** at an interface between the rear housing **108** and the output shaft assembly **110**. The ball bearings **1102**, **1104**, and **1109** provide for robust alignment of the transmission driveline, for example to ensure alignment with upstream and downstream driveline components. Additionally or alternatively, the ball bearings **1102**, **1104**, and **1109** are pressed into respective housing elements to provide for ease of manufacture and/or assembly of the transmission **100**. The number and arrangement of ball bearings in a particular transmission **100** is a design choice, and any provided number and arrangement of ball bearings is contemplated herein.

The example housing assembly **1100** further includes a number of roller bearings **1108**, which may be pressed into respective housing elements, in the example a roller bearing engages each end of the countershafts **902**, **904**. In a further example, a forward end of the countershafts **902**, **904** each engages one of the roller bearings **1108** at an interface between the clutch housing **104** and the main housing **102**, and a rearward end of the countershafts **902**, **904** each engages one of the roller bearings **1108** at an interface between the main housing **102** in the rear housing **108**. The type, number, and location of bearings engaging the countershafts **902**, **904** are design choices, and any provided number, type, and location of bearings are contemplated herein.

In embodiments, one or more bearings, including for various gears of the transmission, may be configured to reduce or cancel thrust loads that occur when the drive shaft for the vehicle is engaged.

Example housing assembly **1100** further includes a cover plate **1110** for the PTO interface **410**, and associated fasteners **1112** (e.g. bolts in the example housing assembly **1100**). A cover plate **1110** may be utilized where a PTO device does not engage PTO interface **410**, such as where no PTO device is present and/or where a PTO device engages a transmission from a rear location or other location. In certain embodiments, for example where transmission **100** does not include the PTO interface **410**, the cover plate **1110** may be omitted. Additionally or alternatively, the transmission **100** included in a system planned to have a PTO device engaging the PTO interface **410** may likewise omit the cover plate **1110**, and/or include a cover plate **1110** that is removed by an original equipment manufacturer (OEM) or other installer of a PTO device.

The example housing assembly **1100** further includes a bearing cover **1114**, where the bearing cover **1114** protects and retains the fourth ball bearing **1109**. Additionally, in certain embodiments, the example housing assembly **1100** further includes a seal **1116**, for example to retain lubricating oil for the output shaft **926** and/or the fourth ball bearing **1109** within the transmission **100**. The presence and type of seal **1116** depend upon the characteristics and type of lubrication system, and may be of any type.

Referencing FIG. **12**, an exploded view **1200** of portions of an open clutch housing **104** consistent with certain embodiments of the present disclosure is schematically depicted. The view **1200** depicts a first cover **1202** corresponding to, in the example, the upper countershaft **902**. The view **1200** further depicts a first cover seal **1204**, wherein the first cover seal **1204** provides for sealing between the first cover **1202** and the clutch housing **104**. The view **1200** further depicts a braking device **922** in exploded view. The example braking device **922** includes a braking disc assembly **1206**. The example braking device **922** includes a braking device actuator **924** depicted as a portion thereof. The example braking device actuator **924** includes a braking piston **1208**, piston seals **1210**, a piston wear ring **1212**, and a braking cover seal **1214**. The example braking cover seal **1214** includes an actuation control input **1216**, for example a pneumatic port coupled to the integrated actuator assembly **1300** positioned in the integrated actuator housing **112**, such as through an air tubing **1226**. Any type of actuation coupling, and/or control are contemplated herein, including at least hydraulic and/or electrical actuation. In certain embodiments, the piston seals **1210** and piston wearing **1212** are positioned in grooves **1218** provided along a bore of the braking piston **1208**. The view **1200** further depicts a second cover seal **1220** and a third cover seal **1222**, as well as a braking cover adapter **1224**. In the example of the view **1200**, the second cover seal **1220** provides sealing between the braking cover adapter **1224** and the clutch housing **104**, and the third cover seal **1222** provides sealing between the braking cover adapter **1224** and the braking cover seal **1214**.

Referencing FIG. **13**, an example integrated actuator assembly **1300** includes an integrated actuator housing **112** and a clutch actuator housing **202**. The example integrated actuator assembly **1300** depicts an example first actuator **908** operationally coupled to a first shift rail **1302** (e.g. a pneumatic rail), an example second actuator **912** coupled to a second shift rail **1304**, and an example third actuator **914** coupled to a third shift rail **1306**. The shape, position, and shift rail positions of the actuators **908**, **912**, **914** are selectable to meet the geometry, actuation force requirements, and the like of a particular application. The example integrated actuator assembly **1300** further includes the clutch actuator **1002** positioned in the clutch actuator housing **202** and operationally coupled to the integrated actuator assembly **1300**. The TCM **114** is depicted as mounted on the integrated actuator assembly **1300**, although the TCM **114** may be positioned elsewhere in a particular transmission **100**. A seal **1308** is provided between the integrated actuator housing **112** and the TCM **114** in the example arrangement. Additional actuation engagement points **1310**, **1312** are provided, for example to operationally couple the sliding clutch **920** and/or the actuator control input **1216** to the integrated actuator assembly **1300**. The position and arrangement of additional actuation engagement points **1310** are non-limiting and may be arranged in any manner. The arrangement depicted in FIG. **13** allows for centralized actuation of active elements of a transmission **100**, while allowing ready access to all actuators for installation, service, maintenance, or other purposes.

Referencing FIG. **14**, a topside view of the integrated actuator assembly **1300** is provided. The integrated actuator assembly **1300** depicts a TCM cover **1402**, which protects and engages the TCM **114** to the integrated actuator housing **112**. A connector **1404** is depicted between the TCM **114** and the integrated actuator housing, with a TCM connector seal **1406** also provided. The arrangement and engagement of the TCM **114** is a non-limiting example. Referencing FIG. **15**, another view of the example integrated actuator assembly **1300** is shown to provide another angle to view details of the assembly. In certain embodiments, all shift rails **1302**, **1304**, **1306**, the clutch actuator **1002**, and the additional actuation engagement points **1310**, **1312** are operated from a single power source coupled to the transmission **100** from the surrounding system or application, and in a further example coupled to a single air power source. The selection of a power source, including the power source type (e.g. pneumatic, electrical, and/or hydraulic) as well as the number of power sources, may be distinct from those depicted in the example. In certain embodiments, additional shift rails and/or actuators may be present, for example to provide for additional gear shifting operations and/or to actuate other devices.

Referencing FIG. **16**, an example lubrication pump assembly **1600** is depicted. The example lubrication pump assembly **1600** is positioned in-line within the transmission rear housing **108** and against the interface to the main housing **102**. The lubrication pump assembly **1600** defines a first hole **1602** therein to accommodate the main driveline passing therethrough, a second hole **1604** therein to accommodate a countershaft (the upper countershaft **902** in the example), and includes a countershaft interface assembly **1606** that engages one of the countershafts (the lower countershaft **904** in the example). The lubrication pump assembly draws from an oil sump **1608** at the bottom of the transmission **100**. In the example transmission **100**, the oil sump **1608** is a dry sump—for example the gears and rotating portions of the transmission do not rotate within the oil in the sump. One of skill in the art will recognize that maintaining a dry sump reduces the losses in rotating elements, as they are rotating in air rather than a viscous fluid, but increases the challenges in ensuring that moving parts within the transmission maintain proper lubrication. Oil may drain to the sump **1608** and be drawn from the sump by the lubrication pump assembly **1600**. In certain embodiments, the sump **1608** is positioned in the rear housing **108**, but may be positioned in the main housing **102** (e.g. with the lubrication pump assembly **1600** positioned within the main housing, and/or fluidly coupled to the main housing), and/or both housings **108**, **102**, for example with a fluid connection between the housings **108**, **102**.

Referencing FIG. **17**, an example lubrication pump assembly **1600** is depicted in exploded view. The example lubrication pump assembly **1600** includes a lubrication pump housing **1702** that couples the lubrication pump assembly **1600** to the transmission **100**, and provides structure and certain flow passages to the lubrication pump assembly. The example lubrication pump assembly **1600** further includes a pump element **1704**, in the example provided as a gear pump, and a relief valve provided as a check ball **1706**, a biasing member **1708**, and a plug **1710** retaining the relief valve. The lubrication pump assembly **1600** further includes a driving element **1712** that couples the pump element **1704** to the engaged countershaft. Additionally, the example lubrication pump assembly **1600** includes a spacer **1714** and a lubrication driveline seal **1716**. The example lubrication pump includes an oil pickup screen **1718** and a screen retainer **1720**. The arrangement of the example lubrication pump assembly **1600** provides for an active lubrication system driven from a countershaft, which operates from a dry sump and includes pressure relief. The arrangement, position, pump type, and other aspects of the example lubrication pump assembly **1600** are non-limiting examples.

Referencing FIG. **18**, an example transmission **100** is depicted. The example transmission **100** includes lubrication tubes provided therein that route lubrication from the lubrication pump assembly **1600** to moving parts within the transmission **100**. The first lubrication tube **1802** is depicted schematically to provide a reference for the approximate position within the transmission **100** where a first lubrication tube **1802** is positioned. The second lubrication tube **1804** is depicted schematically to provide a reference for the approximate position within the transmission **100** where a second lubrication tube **1804** is positioned. The actual shape, position, and routing of any lubrication tubes **1802**, **1804** within a given transmission will depend upon the location and arrangement of the lubrication pump assembly **1600**, the parts to be lubricated, the shape and size of the transmission housing elements, and the like. Accordingly, the first lubrication tube **1802** and second lubrication tube **1804** depicted herein are non-limiting examples of lubrication tube arrangements.

Referencing FIG. **19**, the first lubrication tube **1802** is depicted in a top view and in a bottom view (reference FIG. **20**). Referencing FIG. **21**, a second lubrication tube **1804** is depicted in a side view and a top view (reference FIG. **22**). The lubrication tubes **1802**, **1804** provide for lubrication to all bearings, sleeves, and other elements of the transmission **100** requiring lubrication, and contribute to a lubrication system having a centralized lubrication pump assembly **1600** with short lubrication runs, no external hoses to support the lubrication system, and low lubrication pump losses.

Referencing FIG. **23**, an example main driveline assembly **2102** is depicted schematically, with an angled cutaway view to illustrate certain portions of the main driveline. The main driveline assembly **2102** includes the input shaft **204**, the first mainshaft portion **804**, the second mainshaft portion **806**, and the output shaft **926**. The main driveline assembly **2102** further includes an upper countershaft **902** and a lower countershaft **904**. In the example of FIG. **23**, the lower countershaft **904** engages a braking device (e.g. reference FIG. **12**) at a forward end, and a lubrication pump device (e.g. reference FIGS. **16** and **17**) at a second end. The main driveline assembly **2102** further includes the planetary gear assembly **820** and the driveline adapter **928**. The example main driveline assembly **2102** includes helical gears on the main power transfer path—for example on the countershaft, input shaft, and first mainshaft portion gears.

Referencing FIG. **24**, an example main driveline assembly **2102** is depicted schematically, with no cutaway on the assembly. The planetary gear assembly **820** in the example includes a ring gear **2202** coupled to the output shaft **926**. The sliding clutch **920** engages a sun gear with planetary gears, changing the gear ratio of the planetary gear assembly **820**. Additionally in the view of FIG. **24**, an idler gear **2204** couples one or both countershafts **902**, **904** to the reverse gear **818**. The main driveline assembly **2102** as depicted in FIGS. **23** and **24** is a non-limiting illustration of an example driveline assembly, and other arrangements are contemplated herein. It can be seen in the example arrangement of FIGS. **21** and **22** that torque transfer throughout the transmission **100** occurs across helical gears, is shared between two countershafts reducing the torque loads on each countershaft, and provides for a projecting gear **2206** that extends radially outward at a greater extent from the countershaft **904** to facilitate radial engagement of PTO device. The example arrangement can be seen to be readily manufacturable within a cast housing. Additional features and/or benefits of an example main driveline assembly **2102** are described throughout the present specification. A given embodiment may have certain ones of the example features and benefits. Referencing FIG. **25**, an example main driveline assembly **2102** is depicted schematically in a cutaway view. In certain embodiments, the main driveline assembly **2102** is consistent with other depictions of an example transmission, and the view of FIG. **25** provides a different view of the main driveline assembly **2102** to further illuminate example details.

Referencing FIG. **26**, an example input shaft assembly **2400** is depicted in cutaway view. The example input shaft assembly **2400** includes a snap ring **2402** that retains the first ball bearing **1102**. The example input shaft assembly **2400** further depicts a first synchronizer ring **2404** that engages an input shaft gear **810**, and a second synchronizer ring **2406** that engages a first forward gear **812**. It can be seen in the example of FIG. **26** that engagement with the input shaft gear **810** rotationally couples the input shaft **204** to the countershafts **902**, **904**, and engagement with the first forward gear **812** couples the input shaft **204** to the first mainshaft portion **804** (e.g. when the first main shaft portion **804** is also coupled to the first forward gear **812**) and/or the countershafts (e.g. when the first mainshaft portion **804** is not rotationally coupled to the first forward gear **812**). The example input shaft assembly **2400** further includes a thrust bearing **2408**, a thrust bearing washer **2410**, and a roller needle bearing **2412**. The example input shaft assembly **2400** does not include any taper bearings.

Referencing FIG. **27**, a close up view of an example first actuator **908** assembly **2500** is depicted schematically. The example assembly **2500** includes a synchronizer roller **2502** and the first and second synchronizer rings **2404**, **2406**. A synchronizer biasing member **2504** and synchronizer plunger **2506** position the synchronizer roller **2502** relative to the first actuator **908**, while allowing flexibility during movement caused by shifting operations.

Referencing FIG. **28**, an example first end **2600** of the input shaft **204** is depicted, which in the example of FIG. **28** is the end of the input shaft **204** positioned toward the prime mover. The example end **2600** includes a journal bearing **2602**, with a coiled pin **2604** or similar fastener and a snap ring **2606** cooperating to ensure a desired position of the journal bearing **2602** is maintained. The example features of the input shaft **204** are a non-limiting example, and other configurations at the first end **2600** of the input shaft are contemplated herein. The outer surface **2608** of at least a portion of the input shaft **204** is splined, for example to rotationally engage the clutch **106** to the input shaft, thereby transferring torque from a prime mover output (e.g. a flywheel) to the input shaft **204**.

Referencing FIG. **29**, an example first main shaft portion assembly **2700** is depicted. In certain embodiments, the first main shaft portion **804** may be termed "the main shaft," the second main shaft portion **806** may be termed a "sun gear shaft" or similar term, and the output shaft assembly **110** including the output shaft **926** and driveline adapter **928** may be termed collectively the "output shaft." The naming convention utilized for parts in the transmission **100** is not limiting to the present disclosure, and any naming of parts performing various functions described herein is contemplated within the present disclosure. The example first main shaft portion assembly **2700** includes a seal **2702**, which may be a cup seal, positioned within the first main shaft portion **804** to at least partially seal lubricating oil in the first main shaft portion **804**. The example first main shaft portion assembly **2700** further includes the gears **812**, **814**, **816**, **818** selectively coupled to the main shaft portion **804**. The naming of gears herein—for example the first forward gear **812**, is not related to the "gear" the transmission **100** is operating in—for example "first gear." The gear the transmission **100** operates in is determined by design according to the desired final output ratios of the transmission **100**, and the transmission **100** operating in first gear may imply a number of gear connections within the transmission **100** to provide the implementation of an operational "first gear" for a vehicle or other application. Typically, gear progression occurs from a first gear to a highest gear, with the first gear providing the highest torque amplification (e.g. prime mover torque multiplied by the total gear ratio experienced at the output shaft **926**, and/or further adjusted downstream of the transmission **100** before the load, such as at a rear axle), and the highest gear providing the lowest torque amplification (including an "amplification" ratio less than 1:1, for example in an overdrive gear). Any arrangement of gears and gear progressions are contemplated herein, and not limiting to the present disclosure. In certain embodiments, the transmission **100** operates in direct drive (e.g. all shafts **204**, **804**, **926** spinning at the same speed) and/or in partial direct drive operation (e.g. shafts **204**, **804** spinning at the same speed, and shaft **926** having gear reduction from the planetary gear assembly **820**).

The example first main shaft portion assembly **2700** further includes a mainshaft key **2704**, which may be utilized, for example, to ensure alignment and/or positioning of the first main shaft portion **804**. An example first main shaft portion assembly **2700** further includes a main shaft thrust bearing **2706** configured to accept thrust loads on the first main shaft portion **804**, and a race bearing **2708** configured to accept radial loads on the first main shaft portion **804**. In certain embodiments, the first main shaft portion assembly **2700** does not include any taper bearings. An example first main shaft portion assembly **2700** includes a main shaft snap ring **2710** and a thrust washer **2712**, which cooperate to retain the bearings **2706** and **2708**. The second actuator **912** and third actuator **914** (sliding clutches in the example of FIG. **29**) are operated by shift forks from the integrated actuator assembly **1300** to provide for gear selection on the first main shaft portion **804**. The example first main shaft portion assembly **2700** further includes a synchronizer flange **2714** utilized, in certain embodiments, to couple the input shaft **204** with the first forward gear **812** and/or first main shaft portion **804**.

Referencing FIG. **30**, an example countershaft **904**, the lower countershaft in certain examples of the transmission **100**, is depicted in a detailed view. The example countershaft **904** includes the gears **906** that are rotationally fixed, in certain embodiments, to the countershaft **904**, and that mesh with the gears of the first main shaft portion **804** and/or input shaft **204**. The example countershaft **904** includes a first engagement feature **2802** at a first end for interfacing with a friction brake. In certain embodiments, the friction brake may be termed an "inertia brake," "inertial brake," or the like, although the present disclosure is not limiting to any terminology or type of brake except where context specifically indicates. The friction brake may be any type of braking mechanism known in the art, including at least an electro-magnetic brake and/or a hydraulic brake, and may include any braking actuation understood in the art. Additionally or alternatively, any brake may engage the lower countershaft **904**, the upper countershaft **902**, or both. Where a different number of countershafts **902**, **904** than two countershafts are present, any one or more of the countershafts may be engagable by a brake.

The example countershaft **902** further includes a second engagement feature **2804** configured to interface with a lubrication pump assembly **1600**, for example by a driving element **1712** that keys in to a slot or notch on the countershaft **902**. Any other engagement mechanism between at least one of the countershafts **902**, **904** is contemplated herein, including a friction contact and/or clutch, a belt or chain driving a pump, and/or any other device known in the art.

The example countershaft **902** further includes a roller bearing **1108** positioned at each respective end of the countershaft **902**. Referencing FIG. **31**, a close-up detail of example roller bearings **1108** is depicted, with the first end roller bearing **1108** depicted in FIG. **31**, and the second end roller bearing **1108** depicted in FIG. **32**. The example roller bearing details in FIGS. **31** and **32** depict NUP style cylindrical roller bearings (e.g. having an integral collar in inner race, and a loose collar mounted to the inner race), although any type of cylindrical roller bearing may also be utilized, and in certain embodiments a different type of bearing altogether (e.g. a journal bearing, needle bearing, or other type of bearing) may be utilized depending upon the expected loads, required service life, and other aspects of a particular system. The example countershaft **902** further includes a countershaft snap ring **2902** positioned and configured to retain each respective bearing **1108**, and one or more countershaft thrust washers **2806** (two, in the example of FIG. **30**) positioned on each side of the first end roller bearing **1108**. The number and placement of countershaft thrust washers **2806** are non-limiting, with certain embodiments optionally excluding one or more countershaft thrust washers **2806**, and/or including countershaft thrust washers **2806** associated with the second end roller bearing **1108** according to the loads observed and/or expected in a given transmission **100**.

Referencing FIG. **33**, an example countershaft **902** is depicted. In the example of FIG. **33**, the countershaft **902** corresponds to an upper countershaft in certain embodiments of the transmission **100**, and is substantially similar to the lower countershaft **904** in several aspects. The example countershaft **902** does not include engagement features **2802**, **2804** for a friction brake and/or a lubrication pump assembly **1600**. In certain embodiments, the upper countershaft **902** may engage one or more of the friction brake and/or lubrication pump assembly **1600**, either instead of or in addition to the engagement of the lower countershaft **904**.

Referencing FIG. **34**, an example planetary gear assembly **820** is depicted in cutaway view. The example planetary gear assembly **820** includes the second main shaft portion **806** coupled to a sun gear **3102**, and the sliding clutch **920** that locks up the sun gear **3102**, such that the second main shaft portion **806** directly drives the output shaft **926** (e.g. the sliding clutch **920** in forward position in the example of FIG. **34**). In the locked up position, the planetary gears **3106** revolve around the sun gear **3102**, without any rotation in one example. The sliding clutch **920** selectively couples the sun gear **3102** to planetary gears **3106** (e.g. in a rearward position), which additionally rotate within a ring gear **2202** in addition to revolving, providing gear reduction between the second main shaft portion **806** and the output shaft **926**. The example planetary gear assembly **820** includes a synchronization flange **3108** to transfer rotation from the planetary gears **3106** about the drive axis to the output shaft **926**. The example planetary gear assembly **820** includes a fixed plate **3112** grounded to transmission **100** enclosures (e.g. a rear housing **108**) to fix sun gear **3102** rotation to the planetary gear **3106** rotations, although alternate arrangements for a planetary gear assembly **820** are contemplated herein. In certain embodiments, the third ball bearing **1106** and a thrust washer **3110** take thrust loads, where present. The alignment of ball bearings **1102**, **1104**, **1106**, **1109** for example two on the second main shaft portion **806**, and one on the input shaft **204**, where the input shaft **204** further includes a ball bearing upstream on a prime mover engagement shaft (not shown—e.g. an engine crankshaft), enforces alignment of the driveline through the transmission, allowing the first main shaft portion **804** to float radially while avoiding fulcrum effects and the bearings and consequential additional loads on the transmission gears. The example planetary gear assembly **820** depicts a needle bearing **3118** positioned between the second main shaft portion **806** and the output shaft **926**, and a thrust washer **3114** positioned on the second main shaft portion **806** side of the needle bearing **3118**. The described type and position of bearings, thrust management devices, and the like, as well as the retaining mechanisms for those devices (e.g. the contours of the inner geometry of the second main shaft portion **806** and the output shaft **926** in the example of FIG. **34**) are non-limiting examples, and any arrangement understood in the art is contemplated herein. The example second main shaft portion **806** further includes a lubrication tube **3116**, having holes therein to provide lubrication flow to bearings in fluid communication with the second main shaft portion **806**, and a close tolerance rather than a seal between the lubrication tube **3116** (and/or lubrication sleeve) and the second main shaft portion **806**. The utilization of a close tolerance rather than a seal, in certain embodiments, utilizes resulting leakage as a controlled feature of the lubrication system, reducing losses from both constrained lubrication flow paths and friction from a seal.

Referencing FIG. **35**, a detail view of the sliding clutch **920** and portions of the planetary gear assembly **820** are shown in cutaway view. The sliding clutch **920** engages a planetary synchronizer **3202** in a rearward position, coupling the sun gear **3102** to the planetary gears **3106**, for example through the fixed plate **3112**, which rotate within the ring gear **2202** and provide gear reduction to the output shaft **926**. The sliding clutch **920** in the forward position locks up the sun gear **3102** rotation to the output shaft **926**, providing for direct drive. In the example of FIG. **35**, the second main shaft portion **806** is splined to the first main shaft portion **804**, although alternative arrangements are contemplated in the present disclosure.

Referencing FIG. **36**, a detail view of an example output synchronization assembly **3300** is depicted. The output synchronization assembly **3300** includes the synchronization flange **3108** coupled to the planetary gear assembly **820** to bodily rotate with the planetary gear assembly **820**. As the planetary gears **3106** rotate within the ring gear **2202**, gear reduction through the planetary gear assembly **820** is provided. As the planetary gears **3106** are fixed to the ring gear **2202**, direct drive through the planetary gear assembly **820** is provided. A snap ring (not shown) may be provided to retain planetary gear bearings **3302**, and a needle roller bearing **3304** may be provided between each planetary gear bearing **3302** and the respective planetary gear **3106**. In the example output synchronization assembly **3300**, a thrust washer **3306** is provided at each axial end of the planetary gear bearings **3302**.

Referencing FIG. **37**, a portion of an output shaft assembly **110** is depicted in a combined cutaway and exploded view. The example output shaft assembly **110** includes the driveline adapter **928** and a coupling fastener **3402** (e.g. threaded appropriately to maintain position and/or having a retainer plate **3404**). The example output shaft assembly **110** further includes the fourth ball bearing **1109** coupled to the output shaft **926**, and an O-ring **3406** (e.g. for sealing) and/or a thrust washer **3408** coupled to the fourth ball bearing **1109**. The example output shaft assembly **110** further includes a hub seal **3410** and a slinger assembly **3412**, for example to provide lubrication to the output shaft assembly and/or the fourth ball bearing **1109**.

Referencing FIG. **38**, an example of a portion of planetary gear assembly **820** is depicted in proximity to a rear housing **108**. The planetary gear assembly **820** depicts the planetary gears **3106** rotating on planetary gear bearings **3302** and positioned between a front disc **3502** and a toothed rear disc **3504**. Referencing FIG. **39**, a shift rail **3506** (e.g. operationally coupled to one of the additional actuation engagement points **1310**, **1312** of the integrated actuator assembly **1300**) is operationally coupled to a fourth actuator **3508** (e.g. a shift fork) that operates the sliding clutch **920** to selectively lock up the planetary assembly **820** (providing direct drive) and/or to allow the planetary gears **3106** to rotate within the ring gear **2202** and provide gear reduction across the planetary assembly **820**. The example planetary gear assembly **820** depicts a roll pin **3510** coupling the fourth actuator **3508** to the shift rail **3506**, although any coupling mechanism understood in the art is contemplated herein.

Referencing FIG. **40**, an example transmission **100** is depicted having features consistent with certain embodiments of the present disclosure. The example transmission includes the integrated actuator housing **112** positioned at the top of the transmission **100**, with the TCM **114** mounted thereupon. The transmission **100** includes a number of lift points **412** positioned thereupon. The transmission **100** includes a single power interface **3702** for actuation, for example for a pneumatic input (e.g. an air input port **302**) from a vehicle air supply or other source, which in certain embodiments provides for a single connection to power all shifting and clutch actuators on the transmission **100**. The example transmission **100** further includes the output shaft assembly **110**, configured for certain driveline arrangements, including a driveline adapter **928** coupled to an output shaft with a retainer plate **3404** and coupling fastener **3402**. The example transmission includes a sensor port **304** configured to provide access for a sensor, for example an output shaft speed sensor, and a sensor access **3704** allowing for a sensor to be positioned within the transmission **100**, for example within the rear housing **108** in proximity to a rotating component in the rear housing **108** such as the output shaft **926**. The example transmission **100** further includes the clutch housing **104**, optionally integrated with the integrated actuator housing **112**, and also mounted on the top of the transmission **100** in the example of FIG. **40**. The transmission **100** further includes a second sensor access **3706**, for example providing a location to mount an oil pressure sensor **406**. In one example, the oil pressure sensor **406** couples to a lubrication pump assembly **1600**, providing ready access to determine oil pressure for the transmission **100**. The example transmission **100** further depicts an 8-bolt PTO interface **410** at the bottom of the transmission **100**. In certain embodiments, the transmission **100** does not include a cooling system (not shown), or a cooling interface, to a vehicle or application in which the transmission **100** is installed. Alternatively, an example transmission **100** includes a cooling system (not shown), which may be a contained coolings system (e.g. transmission **100** includes a radiator or other heat rejection device, and is not integrated with a cooling system outside the body of the transmission **100**), and/or an integrated cooling system utilizing cooling fluid, heat rejection, or other cooling support aspects of a vehicle or application. In certain embodiments, one or more housing elements **102**, **104**, **108** are made of aluminum, and/or one or more housing elements are made of cast aluminum. The example transmission **100** includes a minimal number of external hoses and/or lines dedicated for transmission operation, for example zero external hoses and/or lines, a single external line provided as a sensor coupler **404**, a single external line coupling an oil sensor coupler (not shown) that couples an oil pressure sensor **406** to the TCM **114**, and/or combinations of these.

It can be seen that the example transmission **100** depicted in FIG. **40** provides an easily manipulable and integratable transmission **100**, which can readily be positioned in a driveline with a minimal number of connections—for example a single power interface, a wiring harness connection at the electrical connectors **402**, and may require no coolant or other fluid interfaces. In certain embodiments, the transmission **100** is similarly sized to previously known and available transmissions for similar applications, and in certain embodiments the transmission is smaller or larger than previously known and available transmissions for similar applications. In certain embodiments, the transmission **100** includes housing elements **102**, **104**, **108** that provide additional space beyond that required to accommodate the internal aspects of the transmission (gears, shafts, actuators, lubrication system, etc.), for example to match the transmission **100** to an expected integration size and/or to utilize one or more housing elements **102**, **104**, **108** in multiple configurations of the transmission **100** (e.g. to include additional gear layers on the input shaft **204** and/or first main shaft portion **804**). The modular construction of the housing elements **102**, **104**, **108**, gears, shafts, lubrication pump assembly **1300**, and other aspects of the transmission **100** similarly promote re-usability of certain aspects of the transmission **100** across multiple configurations, while other aspects (e.g. clutch housing **104**, main housing **102**, and/or rear housing **108**) are readily tailored to specific needs of a given application or configuration. The example transmission **100** further provides for ready access to components, such as the actuators and/or clutch bearings, which in previously known and available transmissions require more complex access to install, service, integrate, and/or maintain those components. In certain embodiments the transmission **100** is a high output transmission; additionally or alternatively, the transmission **100** is a high efficiency transmission.

The term high output, as utilized herein, is to be understood broadly. Non-limiting examples of a high output transmission include a transmission capable of operating at more than 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, and/or more than 3000 foot-pounds of input torque at a specified location (e.g. at a clutch face, input shaft, or other location in the transmission). Additional or alternative non-limiting examples include a transmission capable of providing power throughput of more than 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 1000, 1500, 2000, 2500, 3000, and/or more than 5000 horsepower, wherein power throughput includes the power processed by the transmission averaged over a period of time, such as 1 second, 10 seconds, 30 seconds, 1 minute, 1 hour, and/or 1 day of operation. Non-limiting examples of a high output transmission include a transmission installed in an application that is a vehicle having a gross vehicle weight exceeding 8500, 14,000, 16,000, 19,500, 26,000, 33,000, up to 80,000, up to 110,000, and/or exceeding 110,000 pounds. Non-limiting examples of a high output transmission include a transmission installed in an application that is a vehicle of at least Class **3**, at least Class **4**, at least Class **5**, at least Class **6**, at least Class **7**, and/or at least Class **8**. One of skill in the art, having the benefit of the disclosures herein, will understand that certain features of example transmissions in the present disclosure may be beneficial in certain demanding applications, while the same or other features of example transmissions may be beneficial in other demanding applications. Accordingly, any described features may be included or excluded from certain embodiments and be contemplated within the present disclosure. Additionally, described examples of a high output transmission are non-limiting, and in certain embodiments a transmission may be a high output transmission for the purposes of one application, vehicle, power rating, and/or torque rating, but not for the purposes of other applications, vehicles, power ratings, and/or torque ratings.

The term "high efficiency," as used herein, is to be understood broadly. A high efficiency transmission is a transmission having a relatively high output value and/or high benefit level, in response to a given input value and/or cost level. In certain embodiments, the high output value (and/or benefit level) is higher than that ordinarily present in previously known transmissions, the given input level (and/or cost level) is lower than ordinarily present in previously known transmissions, and/or a difference or ratio between the high output value (and/or benefit level) and the given input level (and/or cost level) is greater than that ordinarily present in previously known transmissions. In certain embodiments, the output value and/or the input level are within ranges observed in previously known transmissions, but the transmission is nevertheless a high efficiency transmission—for example because the difference or ratio between the high output value and the given input level is high, and/or because other benefits of certain embodiments of the present disclosure are additionally evident in the example transmission. A "high output value" should be understood to encompass a relatively high level of the benefit—for example a lower weight transmission has a higher output value where the weight is considered as the output side of efficiency. A "low input value" should be understood to encompass a relatively low cost or input amount—for example a lower weight transmission has a lower cost value where the weight is considered as the input side of the efficiency. Example and non-limiting output values include a transmission torque level (input, output, or overall gear ratio), a number of available gear ratios, a noise reduction amount, a power loss description, a reliability, durability and/or robustness value, ease of maintenance, quality of service, ease of integration, and/or ease of installation, a responsiveness value (e.g. clutch engagement and/or shifting), a consistency value (e.g. repeatability of operations, consistent driver feel, high degree of matching to a previously known configuration), transmission induced down time values, and/or a service life value. Example and non-limiting input values include a transmission cost, transmission weight, transmission noise level, engineering design time, manufacturing ease and/or cost, installation and/or integration time (e.g. time for the installation, and/or engineering work to prepare the installation plan and/or configure other parts of a vehicle or application to accommodate the transmission), a total cost of ownership value, scheduled maintenance values, average maintenance and/or repair values (e.g. time and/or cost), transmission induced down time values, and/or application constraints (e.g. torque or power limits—absolute, time averaged, and/or in certain gear configurations). The described examples of a high efficiency transmission are non-limiting examples, and any high efficiency descriptions known to one of skill in the art, having the benefit of the disclosures herein, are contemplated within the present disclosure. One of skill in the art, having the benefit of the disclosures herein and information ordinarily known about a contemplated application or installation, such as the functions and priorities related to performance, cost, manufacturing, integration, and total cost of ownership for the application or installation, can readily configure a high efficiency transmission.

It can be further seen that the example transmission **100** provides, in certain embodiments, a reduction in overall bearing and gear loads throughout the transmission **100**, for example through the utilization of high speed countershafts, helical gearing to improve and/or optimize sliding speeds and gear loading, and/or gear tooth shaping to configure gear tooth contact area, structural integrity, and control of sliding speed profiles and deflection of gear teeth. In certain embodiments, the use of high speed countershafts allows smaller and/or lighter components, including at least rotating components (e.g. shafts and gears), bearings, and lubrication systems. In certain embodiments, the utilization of helical gears and/or shaped gear teeth allows for reduction in sliding losses (e.g. increased power transfer efficiency and reduction in heat generated) while also allowing a transmission **100** to meet noise constraints. In certain embodiments, the configuration to allow for noise control allows for certain aspects of the transmission **100** to be configured for other desirable purposes that otherwise would increase the noise emissions from the transmission **100**, such as the use of aluminum housings, configuring for ease of access to shift and/or clutch actuators, the use of a linear clutch actuator, and/or positioning of access to major transmission features, such as actuators, at the top of the transmission which may put them in proximity to a passenger compartment or other noise sensitive area in an application or vehicle. In certain embodiments, the use of helical gearing allows a degree of freedom on thrust (axial) loads, directing thrust loads to selected positions in the transmission **100** such as a support bearing and/or a bearing positioned between shafts having low speed differentials, and/or away from housing enclosures or bearings.

In certain embodiments, the utilization of high speed countershafts additionally or alternatively reduces speed differences between shafts, at least at selected operating conditions, and supports the management of thrust loads in the transmission **100**. In certain embodiments, helical gears on a planetary gear assembly provides for a reduced length of countershafts (e.g. countershafts do not need to extend to the output shaft), a reduction in a number of countershafts (e.g. additional countershafts for power transfer between a main shaft and the output shaft are not required). Additionally or alternatively, helical gears on a planetary gear assembly are load balanced, in certain embodiments, to remove gear loading from enclosures and/or bearings coupled to enclosures. In certain embodiments, features of the transmission **100**, including but not limited to thrust load management features, provide for load management with the use of efficient bearings, for example, with a reduced number of or elimination of tapered bearings in the transmission **100**. In certain embodiments, features of the transmission **100** include a high efficiency lubrication system, for example utilization of a smaller lubrication pump (e.g. short lubrication runs within the transmission **100**, reduction or elimination of spinning shaft slip rings in the transmission **100**, and/or higher pump speed powered by a high speed countershaft), the use of a dry sump lubrication system, and/or the use of a centrally located lubrication pump assembly. In certain embodiments, the transmission **100** provides for lower power transfer losses than previously known transmissions, and/or provides for similar or improved power losses in an overdrive transmission relative to previously known transmission systems using direct drive, allowing for other aspects of a system or application to operate at lower speeds upstream of the transmission (e.g. prime mover speed) and/or higher speeds downstream of the transmission (e.g. a load component such as a driveline, rear axle, wheels, and/or pump shaft) as desired to meet operational goals of those aspects.

In certain embodiments, the transmission **100** utilizes a clutch and shifts gears utilizing actuators that move gear shifting elements or actuators (e.g utilizing shift forks and sliding clutches, with synchronizer elements). An example and non-limiting application for embodiments of the transmission is an automated transmission, and/or a manual automated transmission. Certain aspects and features of the present disclosure are applicable to automatic transmissions, manual transmissions, or other transmission configurations. Certain features, groups of features, and sub-groups of features, may have applicability to any transmission type, and/or may have specific value to certain transmission types, as will be understood to one of skill in the art having the benefit of the present disclosure.

Referencing FIG. **41**, an example clutch operation assembly **3800** is depicted illustrating certain aspects of a clutch assembly and operational portions of the transmission **100** interacting with the clutch assembly. The example clutch operation assembly **3800** provides a clutch **106** that is responsive to a linear clutch actuator **1002**, and that adjusts a position of the clutch **106** such that, as the clutch face wears **306**, the engagement point of the linear clutch actuator **1002** remains constant for a selectable amount of wear on the clutch face **306**. The inclusion of a clutch operation assembly **3800** responsive to a linear clutch actuator **1002**, and/or that provides for a constant engagement point for a linear or concentric clutch actuator, are optional configurations that are included in certain embodiments of the transmission **100**, and may not be included in other embodiments of the transmission **100**. Any clutch operation assembly **3800** known in the art is contemplated herein, including alternate arrangements to provide for engagement with a linear clutch actuator **1002**, and/or alternate arrangements to provide for maintenance of an engagement point for a clutch actuator over a selectable amount of wear on the clutch face **306**. In certain embodiments, the liner actuator **1002** is additionally or alternatively self-adjusting, allowing for the actuating volume for the actuator to remain consistent as the clutch, clutch engagement yoke **808**, linear actuator **1002**, and/or other aspects of the system wear and/or change over the life cycle of the transmission **100**. In certain embodiments, the actuating volume is consistently maintained as a near-zero actuating volume. In certain embodiments, the consistency of the actuating volume and/or a maintained near-zero actuating volume provides for improved response time and improved control accuracy throughout the life cycle of the transmission **100**, and provides for qualitative improvements in clutch operation such as capabilities to utilize the clutch rapidly during shifts (e.g., to mitigate tooth butt events and/or reduce backlash impact on gear meshes).

The example clutch operation assembly **3800** includes the input shaft **204** and the release bearing **1118**, and the clutch face **306** that engages the prime mover. The example clutch operation assembly **3800** further includes a diaphragm spring **3802** that biases the clutch face **306** to an engaged position (toward the prime mover and away from the transmission **100**), and upon actuation by the clutch engagement yoke **808** (e.g. the clutch engagement yoke **808** pushed forward by the clutch actuator **1002**) withdraws the clutch face **306** from the engaged position. Any other actuation mechanism for a clutch is contemplated herein. The clutch operation assembly **3800** further includes a bearing housing **3804** that engages and retains the release bearing **1118**, and further includes a landing face on the release bearing **1118** that engages the clutch engagement yoke **808**.

Referencing FIG. **42**, a portion of the clutch operation assembly **3800** is depicted in exploded view. The clutch operation assembly **3800** includes the clutch **106**, having torsion springs **4202** and a pre-damper assembly **4006** coupled thereto. The clutch operation assembly **3800** includes a pressure plate assembly **4004** and the diaphragm spring assembly bracket **4002**. Referencing FIG. **43**, a detail view of the example pressure plate assembly **4004** is depicted in a perspective view (FIG. **43**) and a side cutaway view (FIG. **44**). The example pressure plate assembly **4004** includes a cam ring **4504** and control fingers **4506** coupled to a pressure plate **4508**. The cam ring **4504** rotates and cooperates with the control fingers **4506** to position the clutch **106** such that, as the clutch face wears **306**, the release bearing **1118** maintains a same position relative to the clutch engagement yoke **808**. Accordingly, even as the clutch face **306** wears, the clutch actuator **1002** returns to the same position within the clutch actuator housing **104**. After a selected amount of wear, the control fingers **4506** prevent further adjustment, and the clutch actuator **1002** will no longer return all the way to the starting point. Accordingly, a high degree of responsiveness and repeatability for clutch engagement is provided in the example transmission **100**, while allowing for diagnostics and/or detection of clutch face **306** wear, where the clutch is still operable but the clutch actuator **1002** return position responds to clutch face **306** wear. The example pressure plate assembly **4004** includes a torsion spring (not shown) coupled to the cam ring **4504** to urge rotation of the cam ring **4504** as the clutch face **306** wears, and a cam baffle **4510** having teeth thereon to prevent counter-rotation of the cam ring **4504**.

Various example embodiments of the present disclosure are described following. Any examples are non-limiting, and may be divided or combined, in whole or part. The example embodiments may include any aspects of embodiments throughout the present disclosure.

Certain embodiments of a high efficiency transmission are described following. The description of certain characteristics as promoting transmission efficiency are provided as illustrative examples. Efficiency promoting characteristics may be included in a particular embodiment, while other characteristics may not be present. Efficiency promoting characteristics may be combined, used in part where applicable, and sub-groupings of any one or more of the described efficiency characteristics may be included in certain embodiments. The description of any feature or characteristic as an efficiency-promoting feature is not limiting to any other feature of the present disclosure also promoting efficiency, and in certain embodiments it will be understood that a feature may promote efficiency in certain contexts and/or applications, and decrease efficiency in other contexts and/or applications.

An example transmission **100** includes one or more housing elements **102**, **104**, **108** that are made at least partially of aluminum. In certain embodiments, housing elements **102**, **104**, **108** may be cast aluminum. The use of aluminum introduces numerous challenges to the performance of a transmission **100**, and in certain embodiments introduces more challenges where the transmission **100** is a high output transmission. For example, and without limitation, aluminum is typically not as strong as steel for a given volume of material, is softer than steel, and has different stress characteristics making it less robust to stress in certain applications. Changes to the stress capability of the housing material have consequences throughout the transmission—for example bolt bosses generally must be deeper for equivalent robustness, and housing enclosures have to be thicker and/or have stress management features for equivalent stresses experienced at the housing. Aluminum also does not insulate noise as well as offset materials, such as steel.

The example transmission **100** includes a power thrust management arrangement that neutralizes, cancels, reduces, and/or redirects the primary power thrust loads experienced within the transmission. In certain embodiments, the power thrust management arrangement redirects thrust loads away from housings and/or transmission enclosures, allowing for reduced strength of the housings with sufficient durability and robustness for a high output transmission. An example power thrust management arrangement includes helical gears in the power transfer line throughout the transmission **100**—for example the countershaft **902**, **904** gear meshes—where the helical gear angles are selected to neutralize, reduce, and/or redirect primary power thrust loads experienced within the transmission **100**. The adjustments of thrust loads may be, in certain embodiments, improved or optimized for certain operating conditions—for example gear ratios likely to be engaged a higher load conditions, gear ratios likely to be involved in higher speed differential operations across thrust bearings, and the like. A gear engagement on the input shaft **204** side of the transmission **100** with the countershaft **902**, **904** has one or more corresponding gear engagements on the first main shaft portion **804** side of the transmission **100** (depending upon the available gear ratios and gear shifting plan), and the thrust management aspects of the helical gears include selected helix angles for the various gear meshes to adjust the thrust profile and thrust duty cycle of the transmission **100**. Certain considerations in determining the helical gear geometries include, without limitation: the load duty cycle for the application, installation, or vehicle (loads and/or speeds, as well as operating time), the gear ratios at each mesh and the duty cycle of opposing gear mesh engagement scenarios, and noise and efficiency characteristics of the helical gear ratio selections. One of skill in the art, having the benefit of the present disclosure and information ordinarily available about a contemplated system, can readily determine helical gear ratios to perform desired power thrust management operations in a transmission **100**. In certain embodiments, thrust loads are redirected to a thrust management device, such as a thrust bearing, which is positioned between rotating shafts having a lowest speed differential (e.g. the input shaft **204** to first main shaft portion **804**). In certain embodiments, the transmission **100** does not include tapered bearings.

An example transmission **100** includes a low loss lubrication system. Losses, in the present instance, refer to overall power consumption from the lubrication system, regardless of the source of the power consumption, and including at least pumping work performed by the lubrication system, viscous losses of moving parts in the transmission **100**, and/or parasitic losses in the lubrication system. The example low loss lubrication system includes a dry sump, wherein the rotating portions of the transmission **100** (e.g. gears, shafts, and countershafts) are not positioned, completely and/or partially, within lubricating fluid in the sump. An example lubrication pump assembly **1600**, drawing lubrication fluid for the pump from the rear housing **108**, provides a non-limiting example of a lubrication system having a dry sump. An example low loss lubrication system further includes a centralized lubrication pump, such that lubrication paths within the transmission **100** have a shortened length, and/or a reduced or optimized overall length of the lubrication channels. An example lubrication pump assembly **1600**, integrated within the transmission **100** and coupled to a countershaft or other rotating element of the transmission **100**, provides a non-limiting example of a centralized lubrication system. In certain embodiments, utilization of centralized lubrication tubes **1802** and/or **1804** provide for reduced-length runs of lubrication channels. Additionally or alternatively, an example transmission **100** includes a lubrication tube positioned inside the first main shaft portion and/or second main shaft portion, having holes therein to provide a portion of the lubrication paths to one or more bearings, and additionally or alternatively does not include seals on the lubrication tube. In certain further embodiments, a low loss lubrication system includes a lubrication pump driven by a high speed countershaft, where the high speed of the countershaft provides for a higher lubrication pump speed, thereby allowing for a smaller lubrication pump to perform lubrication pumping operations, reducing both pumping losses and/or weight of the lubrication pump and/or associated lubrication pump assembly **1600**.

An example transmission **100** includes one or more high speed countershafts **902**, **904**. The term "high speed" with reference to countershafts, as utilized herein, is to be understood broadly. In certain embodiments, a high speed countershaft rotates at a similar speed to the input shaft **204** and/or the first main shaft portion **804**, for example at the same speed, within +/−5%, +/−10%, +1-15%, +/−20%, +/−25%, and/or within +/−50% of the speed of the input shaft **204** and/or first main shaft portion **804**. In certain embodiments, a high speed countershaft has a higher relative speed than a countershaft in an offset transmission for a similar application, where similarity of application may be determined from such considerations as power rating, torque rating, torque multiplication capability, and/or final load output and/or duty cycle. A speed that is a high relative speed to an offset transmission includes, without limitation, a speed that is at least 10% higher, 20% higher, 25% higher, 50% higher, 100% higher, up to 200% higher, and greater than 200% higher. In certain embodiments, utilization of high speed countershafts **902**, **904**, allows for smaller devices operating in response to the rotational speed of the countershafts—for example a lubrication pump driven by a countershaft **902**, **904**. In certain embodiments, a PTO device driven by one of the countershafts can utilize the higher countershaft speed for improved performance. In certain embodiments, utilization of high speed countershafts **902**, **904** allows for reductions of gear and bearing components, as the countershaft operates at a speed closer to the input shaft and/or first main shaft portion speed than in a previously known transmission, providing for lower loads on meshing gears and bearings, and/or providing for more rapid gear shifts with lower losses (less time to shift, and/or less braking to bring the countershaft speed closer to the engaging speed, for example on an upshift). In certain embodiments, lower loads on the countershafts, due to the high speed configuration and/or a twin configuration sharing loads, allows for the countershaft to be a lower size and/or weight. In certain embodiments, the twin countershafts provide for noise reduction, for example from reduced size of engaging components and/or lower engagement forces. Additionally or alternatively, lower rotational inertia from the countershafts has a lower effect on clutch speed during shifts—for example through transfer of countershaft inertia to the clutch before clutch re-engagement, allowing for a faster and lower loss (e.g. lower braking applied to slow the system back down) shifting event.

In certain embodiments, a gear ratio at the front of the transmission **100** is lower relative to a gear ratio at the rear of the transmission **100**. In certain embodiments, providing greater torque amplification at the rear of the transmission (e.g. from the countershaft(s) to the second main input shaft portion **804**) than at the front of the transmission **100** (e.g. from the input shaft **204** to the countershaft(s)) provides for more efficient (e.g. lower losses) power transfer than more evenly stepping up torque amplification. For example, a total ratio of 4:1 provided as a first step of 1:1 and a second step of 4:1 for most example transmissions **100** provides for a lower loss power transfer than a first step of 2:1 and a second step of 2:1, while providing the same overall torque amplification. In certain embodiments, a rear:front amplification ratio is greater than 1.5:1, greater than 2:1, greater than 2.5;1, greater than 3:1, greater than 3.5:1, greater than 4:1, greater than 4.5:1, and/or greater than 5:1. For example, where an overall torque amplification ratio of 5:1 is desired, an example transmission includes a front transfer of 1.25:1 and a rear transfer of 4:1. The described ratios and embodiments are non-limiting examples. One of skill in the art, having the benefit of the disclosures herein, will readily appreciate that, in certain embodiments, high speed countershafts facilitate lower front torque amplification ratios—for example at a torque amplification ratio near unity (1), gear teeth count between the countershaft and the input shaft are also near unity, and accordingly gear sizes can be kept low if the countershaft turns at a high rate of speed. In certain embodiments, a high speed countershaft facilitates selection of gear sizes to meet other constraints such as providing an interface to a PTO device, providing for gear geometries within a transmission **100** to facilitate manufacture and assembly within a cast housing, and/or to keep gear outer diameters in a normal range. Gear sizes provided within a normal range—i.e. not constrained to be large on either the input shaft **204** and/or the countershaft **902**, **904** by torque amplification requirements—allow for controlling torsional forces on the shafts and gear fixing mechanisms (e.g. welds and/or synchronizer devices) low and/or controlling a final geometric footprint of the housing (e.g. the main housing **102**) to provide for a compact and/or easily integrated transmission **100**.

In certain embodiments, a twin countershaft arrangement provides for balanced forces on the input shaft **204** and/or first main shaft portion **804**, and lower cost bearings at one or more gear locations on the input shaft **204** and/or first main shaft portion **804** are provided—for example a journal bearing, bushing, a washer, and/or a race bearing. In certain embodiments, a needle bearing is provided at one or more gear locations on the input shaft **204** and/or the main shaft portion **804**, for example on a gear expected to take a radial load, including, for example, a gear on the input shaft **204** close to the power intake for the transmission **100**, and/or a gear coupled to the countershaft for powering a PTO device.

In certain embodiments, helical gearing on the countershafts **902**, **904** and meshing gears thereto provides for high efficiency operation for the transmission **100**. For example, helical gearing provides for thrust management control of the power transfer in the transmission, allowing for lower weight and cost components, such as bearings. Additionally or alternatively, thrust management control of the gears allows for reduced housing weight and/or strength for a given power or torque throughput. Additionally or alternatively, helical gear engagement allows for reduced noise generation, allowing for greater engagement force between gears for a given noise level. Additionally or alternatively, helical gears are easier to press and time relative to, for example, spur gears—allowing for a reduced manufacturing cost, improved manufacturability, and/or more reliable gear mesh. Additionally or alternatively, helical gears provide a greater contact surface for gear teeth, allowing for lower contact pressure for a given contact force, and/or lower face width for the gear teeth while providing gear teeth that are readily able to bear contact loads.

In certain embodiments, a transmission **100** is provided without tapered bearings in the drive line. In certain embodiments, a transmission **100** has a reduced number of tapered bearings in the drive line relative to an offset transmission in a similar application. Tapered bearings are typically utilized to control both thrust loads and radial loads. In certain embodiments, a transmission **100** includes features to control thrust loads, such that tapered bearings are not present. Taper rollers on a bearing require shimming and bearing clearance settings. In certain embodiments, tapered bearings reduce power transfer efficiency and generate additional heat in the transmission. In certain embodiments, main bearings in an example transmission **100** are positioned (e.g. pressed) in the housing elements **102**, **104**, **108**, and shafts in the driveline are passed therethrough. An example transmission **100** is assembled positioned vertically, with shafts passed through the pressed bearings, and where no bearing clearances and/or shims need to be made, the main housing **102** is coupled to the clutch housing **104** during vertical assembly, and the rear housing **108** is coupled to the main housing **102** to complete the housing portion of the vertical assembly. In certain embodiments, an example transmission **100** may be constructed horizontally or in another arrangement, and/or vertically with the rear housing **108** down.

In certain embodiments, power transfer gears in the transmission **100** (e.g. at the countershaft meshes) gear teeth have a reduced height and/or have a flattened geometry at the top (e.g. reference FIG. **24**—teeth have a flattened top profile). The use of shortened teeth provides for lower sliding velocities on gear teeth (e.g. increased power transfer efficiency) while allowing the teeth to engage in a high power transfer efficiency operation. The shortened gear teeth, where present, additionally experience lower deflection than occurs at the top of previously used gear teeth geometries, providing greater control of one noise source and improved service life of the gear teeth. In certain embodiments, the use of helical gears with a flattened tooth geometry allows for further noise control of flattened gear teeth and/or high power transfer loads. In certain embodiments, a low tolerance and/or high quality manufacturing operation for the gear teeth, such as the use of a wormwheel to machine gear teeth, provides for a realized geometry of the gear teeth matching a design sufficiently to meet noise and power transfer efficiency targets. In certain embodiments, a worm wheel is utilized having a roughing and finishing grit applied in one pass, allowing gear tooth construction to be completed in a single pass of the worm-wheel and leave a selected finish on the gear tooth.

In certain embodiments, the transmission **100** includes thrust loads cancelled across a ball bearing, to control thrust loads such that no bearings pressed into a housing enclosure take a thrust load, to control thrust loads such that one or more housing elements do not experience thrust loads, to control thrust loads such that a bearing positioned between low speed differential shafts of the transmission (e.g. between an input shaft **204** and a first main shaft portion **804**) take the thrust loads, and/or such that thrust loads are cancelled and/or reduced by helical gears in power transfer gear meshes. In certain embodiments, bearings pressed into a housing element, and/or one or more housing elements directly, are exposed only to radial loads from power transfer in the transmission **100**.

In certain embodiments, a transmission **100** includes a PTO interface **410** configured to allow engagement of a PTO device to one of the countershafts from a radial position, for example at a bottom of the transmission **100**. An example transmission **100** includes gear configurations such that a radially extending gear from one of the countershafts **902**, **904** is positioned for access to the extending gear such that a gear to power a PTO device can be engaged to the extending gear. Additionally or alternatively, a corresponding gear on one of the input shaft **204** and/or first main shaft portion **804** includes a needle bearing that accepts radial loads from the PTO engagement. In certain embodiments, the countershafts **902**, **904** do not include a PTO engagement gear (e.g. at the rear of the countershaft), and the transmission **100** is configured such that driveline intent gears can be utilized directly for PTO engagement. Accordingly, the size and weight of the countershafts is reduced relative to embodiments having a dedicated PTO gear provided on one or more countershafts. In certain embodiments, a second PTO access (not shown) is provided in the rear housing, such that a PTO device can alternatively or additionally engage at the rear of the transmission. Accordingly, in certain embodiments, a transmission **100** is configurable for multiple PTO engagement options (e.g. selectable at time of construction or ordering of a transmission), including a 8-bolt PTO access, and/or is constructed to allow multiple PTO engagement options after construction (e.g. both PTO access options provided, such as with a plug on the rear over the rear PTO access, and an installer/integrator can utilize either or both PTO access options).

An example transmission **100** includes only a single actuator connection to power actuators in the transmission, for example an air input port **302** provided on the integrated actuator housing **112**. A reduction in the number of connections reduces integration and design effort, reduces leak paths in the installation, and reduces the number of parts to be integrated into, and/or fail in the installed system. In certain embodiments, no external plumbing (e.g. lubrication, coolant, and/or other fluid lines) is present on the transmission **100**. In certain embodiments, the transmission **100** is a coolerless design, providing less systems to fail, making the transmission **100** more robust to a cooling system failure of the application or vehicle, reducing installation connections and integration design requirements, reducing leak paths and/or failure modes in the transmission and installed application or vehicle, and reducing the size and weight footprint of the transmission **100**. It will be recognized that certain aspects of example transmissions **100** throughout the present disclosure support a coolerless transmission design, including at least transmission power transfer efficiency improvements (e.g. generating less heat within the transmission to be dissipated) and/or aluminum components (e.g. aluminum and common aluminum alloys are better thermal conductors than most steel components). In certain embodiments, heat fins can be included on housing elements **102**, **104**, **108** in addition to those depicted in the illustrative embodiments of the present disclosure, where additional heat rejection is desirable for a particular application. In certain embodiments, an example transmission **100** includes a cooler (not shown).

In certain embodiments, a transmission **100** includes an organic clutch face **306**. An organic clutch face provides for consistent and repeatable torque engagement, but can be susceptible to damage from overheating. It will be recognized that certain aspects of example transmissions **100** throughout the present disclosure support utilization of an organic clutch face **306**. For example, the linear clutch actuator **1002**, and clutch adjustment for clutch face wear providing highly controllable and repeatable clutch engagement, allow for close control of the clutch engagement and maintenance of clutch life. Additionally or alternatively, components of the transmission **100** providing for fast and smooth shift engagements reduce the likelihood of clutch utilization to clean up shift events—for example the utilization of high speed countershafts, lower rotational inertia countershafts, helical gears, efficient bearings (e g management of shaft speed transients relative to tapered bearing embodiments), and/or compact, short-run actuations for gear switching with an integrated actuator assembly. In certain embodiments, elements of the transmission **100** for fast and smooth shift engagements improve repeatability of shift events, resulting in a more consistent driver feel for a vehicle having an example transmission **100**, and additionally or alternatively the use of an organic clutch face **306** enhances the ability to achieve repeatable shift events that provide a consistent driver feel.

In certain embodiments, a transmission **100** is configurable for a number of gear ratios, such as an 18-speed configuration. An example 18-speed configuration adds another gear engaging the input shaft **204** with a corresponding gear on the countershaft(s). The compact length of the example transmissions **100** described herein, combined with the modular configuration of housing elements **102**, **104**, **108** allow for the ready addition of gears to any of the shafts, and accommodation of additional gears within a single housing configuration, and/or isolated changes to one or more housing elements, while other housing elements accommodate multiple gear configurations. An example 18-speed configuration is a 3×3×2 configuration (e.g. 3 gear ratios available at the input shaft **204**, 3 forward gear ratios on the first main shaft portion **804**, and 2 gear ratios available at the second main shaft portion **806**). Additionally or alternatively, other arrangements to achieve 18 gears, or other gear configurations having more or less than 12 or 18 gears are contemplated herein.

In certain embodiments, certain features of an example transmission **100** enable servicing certain aspects of the transmission **100** in a manner that reduces cost and service time relative to previously known transmissions, as well as enabling servicing of certain aspects of the transmission **100** without performing certain operations that require expensive equipment and/or introduce additional risk (e.g. "dropping the transmission," and/or disassembling main portions of the transmission **100**).

An example service event **5600** (reference FIG. **45**) includes an operation **5602** to access an integrated actuator assembly, by directly accessing the integrated actuator assembly from an external location to the transmission. In certain embodiments, the integrated actuator assembly is positioned at the top of the main housing **102**, and is accessed in single unit having all shift and clutch actuators positioned therein. In certain embodiments, one or more actuators may be positioned outside of the integrated actuator assembly, and a number of actuators may be positioned within or coupled to the integrated actuator assembly. Direct access to an integrated actuator assembly provides, in certain embodiments, the ability to install, service, and/or maintain actuators without dropping the transmission, disassembling main elements of the transmission (including at least decoupling one or more housings, the clutch, any bearings, any gears, and/or one or more shafts). Additionally or alternatively, the example service event **5600** includes an operation **5604** to decouple only a single actuator power input, although in certain embodiments more than one actuator power input may be present and accessed. The example service event **5600** includes an operation **5606** to service the integrated actuator assembly, such as but not limited to fixing, replacing, adjusting, and/or removing the integrated actuator assembly. The term "service event," as utilized herein, should be understood to include at least servicing, maintaining, integrating, installing, diagnosing, and/or accessing a part to provide access to other parts in the transmission **100** or system (e.g. vehicle or application) in which the transmission is installed.

An example service event **5900** (reference FIG. **46**) includes an operation **5902** to access a journal bearing **2602** positioned at an engagement end of the input shaft **204**. The engagement end of the input shaft **204** engages the prime mover, for example at a ball bearing in the prime mover (not shown), and the engagement end of the input shaft **204** can experience wear. The inclusion of a journal bearing **2602**, in certain embodiments, provides for ready access to replace this wear part without removal and/or replacement of the input shaft **204**. The example service event **5900** further includes an operation **5904** to remove the journal bearing **2602**, and an operation **5906** to replace the journal bearing **2602** (for example, after fixing the journal bearing **2602** and/or replacing it with a different part). The example service event **5900** describes a journal bearing **2602** positioned on the input shaft **204**, however the journal bearing **2602** may be any type of wear protection device, including any type of bearing, bushing, and/or sleeve.

Referencing FIG. **47**, a perspective view of an example clutch housing **104** consistent with certain embodiments of the present disclosure is depicted. The clutch housing **104** includes an interface portion **4702** that allows for coupling to a prime mover. The modularity of the clutch housing **104** allows for ready configuration and integration for specific changes, for example providing an extended or split input shaft to add a gear layer to the input shaft without significantly altering the footprint of the transmission **100**, or requiring redesign of other aspects of the transmission **100**, while maintaining consistent interfaces to the prime mover.

Referencing FIG. **48**, another perspective view of an example clutch housing **104** consistent with certain embodiments of the present disclosure is depicted. The clutch housing **104** includes a second interface portion **4808** that allows for coupling to a main housing **102**. The modularity of the clutch housing **104** allows for ready configuration and integration for specific changes, for example providing an extended or split input shaft to add a gear layer to the input shaft without significantly altering the footprint of the transmission **100**, or requiring redesign of other aspects of the transmission **100**, while maintaining consistent interfaces to the main housing **102**. The example clutch housing **104** further includes holes **4802** for countershafts in a bulkhead (or enclosure) formed on the main housing **102** side of the clutch housing **104**, and a hole **4804** for passage of the input shaft therethrough. The integral bulkhead holes **4802**, **4804** provide for mounting of bearings and shafts, and for ready assembly of the transmission **100**.

Referencing FIG. **49**, a perspective view of an example rear housing **108** consistent with certain embodiments of the present disclosure is depicted. The rear housing **108** includes an interface portion **4902** that allows for coupling to a main housing **102**. The modularity of the rear housing **108** allows for ready configuration and integration for specific changes, for example providing a rear PTO interface **5102** (see the disclosure referencing FIG. **51**) or other alterations to the rear housing **108**, without significantly altering the footprint of the transmission **100**, or requiring redesign of other aspects of the transmission **100**. Referencing FIG. **50**, another perspective view of the rear housing **108** is depicted. The rear housing **108** includes a driveline interface **5002**, for example to couple with a driveshaft or other downstream component. Referencing FIG. **51**, a perspective view of another example rear housing **108** is depicted, providing a rear PTO interface **5102**.

Referencing FIG. **52**, a perspective view of an example lubrication pump assembly **1600** consistent with certain embodiments of the present disclosure is depicted. The driving element **1712**, coupling the lubrication pump **1704** to one of the countershafts, is visible in the perspective view of FIG. **52**. The modularity of the lubrication pump assembly **1600** allows for ready configuration and integration for specific changes, for example providing an alternate pump sizing or gear ratio, while maintaining consistent interfaces to the rest of the transmission **100**. Referencing FIG. **53**, another perspective view of an example lubrication pump assembly **1600** is depicted. An oil pickup screen **1718** and screen retainer **1720** is visible in the view of FIG. **53**.

Referencing FIG. **54**, a perspective view of an example main housing **102** consistent with certain embodiments of the present disclosure is depicted. The example of FIG. **54** has a connector for a transmission control module, but the transmission control module is not installed. The main housing **102** includes interfaces **5402**, **5404** (see the portion of the disclosure referencing FIG. **56**) providing consistent interfaces to the rear housing **108** and clutch housing **104**. A clutch actuator housing **202**, which may be coupled to or integral with an integrated actuator housing **112** is visible in the view of FIG. **54**. Referencing FIG. **55**, a transmission control module **114** (TCM), and a TCM retainer **5502** (e.g., a TCM cover **1402**) are depicted as installed on a transmission **100**. Referencing FIG. **56**, an 8-bolt PTO interface **410** is depicted, which may be optionally not present or capped, without affecting the footprint or interfaces of the main housing **102**. Referencing FIG. **57**, a bottom view of an example main housing **102** is depicted, providing a clear view of an example 8-bolt PTO interface **410**. Referencing FIG. **58**, a perspective view of an example main housing **102** is depicted, including an actuator interface **5802** whereupon actuators for shifting, clutch control, and/or a friction brake can be installed. Accordingly, the main housing **102** can accommodate various actuation assemblies, including an integrated actuation assembly, without changing the footprint or interfaces of the main housing **102** with the rest of the transmission **100**.

Referencing FIG. **94**, an example controller **17110** includes a backlash indication circuit **18002** that identifies an imminent backlash crossing event **18006** at a first gear mesh, and a backlash management circuit **9402** that reduces engagement force experienced by the first gear mesh in response to receiving a backlash crossing indication event **18006** from the backlash indication circuit **18002**. The example controller **17110** further includes a shaft displacement circuit **9602** that interprets a shaft displacement angle **9604**, the shaft displacement angle **9604** including an angle value representative of a rotational displacement difference between at least two shafts of a transmission. The example controller **17110** further includes a zero torque determination circuit **9806** that determines the transmission is operating in a zero torque region **9808** in response to the shaft displacement angle **9604** including a difference value below a zero torque threshold value **9814**, and where the backlash indication circuit **18002** further identifies the imminent backlash crossing event **18006** in response to the transmission operating in the zero torque region **9808**. Example operations of the backlash indication circuit **18002** to identify the imminent backlash crossing event **18006** include operations such as: determining that an imminent rotational direction of the first gear mesh in a transmission is an opposite rotational direction to an established rotational direction of the first gear mesh; determining that a speed change between a first shaft comprising gears on one side of the first gear mesh and a second shaft comprising gears on an opposing side of the first gear mesh is likely to induce the backlash crossing event; determining that a gear shift occurring at a second gear mesh is likely to induce the backlash crossing event at the first gear mesh; determining that a transmission input torque value indicates an imminent zero crossing event; and/or determining that a vehicle operating condition is likely to induce the backlash crossing event. An example backlash management circuit **9402** further manages backlash by performing an operation such as disengaging the first gear mesh during at least a portion of the backlash crossing event; disengaging a clutch during at least a portion of the backlash crossing event; and/or slipping a clutch during at least a portion of the backlash crossing event. An example backlash indication circuit **18002** identifies the imminent backlash crossing event **18006** by determining that a gear shift occurring at a second gear mesh is likely to induce the backlash crossing event **18006** at the first gear mesh, where the backlash management circuit **9402** further performs a disengagement of the first gear mesh during at least of portion of the gear shift.

Embodiments depicted in FIGS. **59-64**, and all related descriptions thereto, are compatible in certain aspects to embodiments depicted in FIGS. **1-58** and all related descriptions thereto. Accordingly, each aspect described in FIGS. **59-64** is contemplated as included, at least in one example, with any compatible embodiments described in FIGS. **1-58**. For purposes of illustration of certain disclosed features or principles, certain more specific relationships are described between embodiments depicted in FIGS. **1-58** and embodiments depicted in FIGS. **59-64**, and additionally between disclosed embodiments within FIGS. **1-58** individually, and disclosed embodiments within FIGS. **59-64** individually. Such additional specifically described relationships are not limiting to other relationships not specifically described. One of skill in the art will recognize compatible embodiments between all of the disclosed examples herein, and any such compatible embodiments, in addition to any specific relationships described, are contemplated herein.

Referencing FIG. **59**, an example system **9500** is depicted schematically, and includes a transmission **100** having an input shaft **204** and an output shaft **926**, the input shaft **204** selectively accepting a torque input from a prime mover **9502**, and the output shaft **926** selectively providing a torque output to a driveline **9504**. In certain embodiments, the input shaft **204** and the output shaft **926** are coupled through gear arrangements provided on one or more additional shafts, such as a main shaft **9508** and/or a countershaft **902**. The system **9500** further includes a controller **9506**, the controller **9506** performing operations to interpret a shaft displacement angle, where the shaft displacement angle includes an angle value representative of a rotational displacement difference between at least two shafts of the transmission **100**. The controller **9506** further performs a transmission operation in response to the shaft displacement angle. Further details of operations of the controller **9506** are described in the disclosure referencing FIG. **60** following.

Referencing FIG. **60**, an apparatus **9600** includes a controller **9506** having a shaft displacement circuit **9602** that interprets a shaft displacement angle **9604**, where the shaft displacement angle **9604** includes an angle value representative of a rotational displacement difference between at least two shafts of the transmission. Example and non-limiting operations to interpret the shaft displacement angle **9604** include: receiving the shaft displacement angle **9604** as a parameter from outside the controller **9506**, for example receiving the shaft displacement angle **9604** as a network or datalink communication, and/or reading the shaft displacement angle **9604** from a memory location on a non-transient memory; determining the shaft displacement angle **9604** from sensor information, such as an optical sensor that determines shaft positions and/or shaft relative positions in real-time on an operating transmission; determining high resolution shaft positions utilizing an electro-magnetic sensor package, such as: hall effect sensors, variable reluctance sensors, and/or other electro-magnetic effect sensors in proximity to each shaft of interest, wherein the shaft includes sufficient magnetically responsive marking features to determine shaft positions with a selected degree of accuracy; one or more virtual sensors processing shaft speeds and gear configurations (including at least real-time gear engagements and tooth configurations for the gears in the transmission) to determine relative angles of the shafts of interest; providing an indexing feature (e.g. a tone wheel or a perforated wheel) rotationally coupled to each shaft of interest, where detection of the indexing feature position can determine the angles of the shafts of interest; and combinations of these.

The controller **9506** further includes a displacement response circuit **9606** that performs a transmission operation **9608** in response to the shaft displacement angle **9604**. Example and non-limiting transmission operations **9608** include a command **9610** to modulate a clutch operation, a command **9612** to modulate a shift actuator operation, a command **9614** to modulate a friction brake operation, and/or an external communication **9616** (relative to the transmission **100**) such as a request, command, notification, or other system response to a component in a system outside the transmission, such as a vehicle or engine.

The system **9500** further includes, in certain embodiments, the countershaft **902** selectively coupled to the input shaft **204** at a first end, and selectively coupled to the output shaft **926** at a second end. In the example system **9500**, the countershaft **902** is selectively coupled to the output shaft **926** at the second end through the main shaft **9508**, although any coupling arrangement of the countershaft **902** to the output shaft **926** is contemplated herein, including at least direct coupling and/or coupling through other device than a main shaft **9508**. The system **9500** further includes an example shaft displacement angle **9604** being an input angle, where the input angle includes an angle value representative of a rotational displacement difference between the input shaft **204** and the countershaft **902**. The rotational displacement difference may be any rotational angle description and convention, for example an angle degree number indicating a difference in the rotational angles of the shaft (e.g. −5 would indicate a 5 degree rotational difference in the direction indicated by the negative sign, such as driving rotational angle, coasting rotational angle, clockwise when viewed from a selected end of the shafts, counterclockwise when viewed from a selected end of the shafts, or any other convention). Further, the sign convention may be any convention, such as countershaft **902** rotational difference to input shaft **204**, or input shaft **204** rotational difference to the countershaft **902**. Additionally or alternatively, a value indicating rotational alignment may be any value and not necessarily zero—for example an angle indicating contact on a drive side rotation without torque applied may be selected as zero, an angle indicating contact on a coast side rotation without torque applied may be selected as zero, and/or an arbitrary angle may be selected as zero. For convenience and clarity of the description herein, zero is described as no rotational displacement between the shafts, although any convention is contemplated herein.

Referencing FIG. **61**, an example apparatus **9700** includes a controller **9506** having a shift state description circuit **9706** that determines that a synchronizer (not shown) is unblocked in response to the input angle **9702**. A shift actuator in the system includes, without limitation, a shift fork and/or shift claw, which moves gear couplers and/or synchronizers to engage gear meshes between the shafts **204**, **902**, **9508**, **926**, and thereby provide for a selected torque multiplication and direction of the transmission **100**. In certain embodiments, the displacement response circuit **9606** further provides a shift engagement command **9704** in response to the determining the synchronizer is unblocked, where a system **9500** further includes a shift actuator (not shown) responsive to the shift engagement command **9704**. A synchronizer being unblocked, as used herein, indicates that the synchronizer has brought shaft speeds close together, teeth for the gear couplers are not blocked and that shift actuator can proceed to fully engage the gear coupler and complete a shift. The moment of synchronizer unblocking is a highly transient event and is difficult to detect in previously known transmissions. Upon unblocking, the shift actuator may proceed with the engagement with little resistance, and the gear coupler may impact with significant velocity, causing an audible engagement, a perception of poor shift quality from a driver or operator, and/or cause excessive part wear. In certain embodiments, the shift state description circuit **9706** is able to determine a transition from synchronizer traversal (e.g. the shift actuator proceeding down a shift rail toward the gear engagement) to a synching phase (the synchronizer is "sitting on the block") where the synchronizer is bringing the shaft speeds together by determining that a noticeable slope change occurs in the input angle **9702** (or other relevant shaft displacement angle **9604**), and further determines that the synchronizer is unblocked by determining that a slop change in the input angle **9702** (or other relevant shaft displacement angle **9604**) has experienced another slope change, by determining the input angle **9702** has departed from the slope occurring during the synching phase, and/or by determining that an abrupt change in magnitude occurs in the input angle **9702**.

An example controller **9506** includes a shift actuation circuit **9708** that provides a shift opposition command **9710** in response to the shift state description circuit **9706** determining the synchronizer is unblocked. The example system **9500** includes the shift actuator further responsive to the shift opposition command **9710**. An example shift opposition command **9710** includes a pneumatic pressure applied in an opposing direction to the shift engagement (e.g. opposing the motion of the shift actuator toward engagement), although any type of actuator response opposing shift engagement is contemplated herein. The shift opposition command **9710** applies an opposing force that provides some resistance to the final engagement of the gear coupler during final engagement when the synchronizer is off the block, reducing noise, wear, and improving driver or operator comfort and perception of the shift.

An example controller **9506** includes the shift engagement command **9704** as an increased actuation pressure (e.g. in a pneumatic system) relative to a decreased actuation pressure applied during a synchronization operation. For example, the shift engagement command **9704** may provide for a reduced actuation pressure when the synchronizer is on the block, reducing pressure buildup during the synchronization and reducing engagement force, part wear, and potential noise. An example shift engagement command **9704**, in the presence of an available shift opposition command **9710** responsive to the shaft displacement angle **9604**, can increase the actuation pressure during traverse of the rail toward engagement of the synchronizer and/or gear coupler, as the shift opposition command **9710** can be utilized to reduce engagement forces as the synchronizer approaches engagement, and when the synchronizer is unblocked.

An example shift opposition command **9710** includes an increased opposition pressure to a movement of a shift actuator relative to a synchronization opposition pressure. For example, as the synchronizer approaches engagement, the shift opposition command **9710** may be utilized to provide a synchronization opposition pressure **9712** to reduce impact velocity of the synchronizer and/or gear couple during engagement. An example shift opposition command **9710** further increases opposition pressure to movement of the shift actuator as the synchronizer comes off the block, to reduce the engagement velocity which may be increased to the removal of resistance to movement of the shift actuator. In certain embodiments, the synchronization opposition pressure **9712** includes an opposition pressure during a synchronization operation and/or a synchronizer approach operation, and the increased opposition pressure **9714** includes an amount of additional opposition pressure relative to the synchronization opposition pressure, where the additional opposition pressure is selected to reduce a final engagement velocity of the shift actuator.

In certain embodiments, the shift state description circuit **9706** further determines the synchronizer is unblocked in response to a rate of change of the input angle, in response to a rate of change of the input angle transitioning from a first rate of change to a second rate of change, and/or where the first rate of change is associated with a synching position of the shift actuator, and wherein the second rate of change is associated with synchronizer unblock position of the shift actuator. In certain embodiments, the greatest engagement forces and torque transients occur at a forward-most gear mesh in the transmission **100**. An example system **9500** further includes a gear mesh between a first gear on the countershaft **902**, and a second gear on the input shaft **204**, being a forward-most gear mesh in the transmission **100**.

An example system **9500** includes the transmission **100** having a countershaft **902** selectively coupled to the input shaft **204** at a first end, and selectively coupled to the output shaft **926** at a second end, where the countershaft is selectively coupled to the output shaft **926** at the second end via a main shaft **9508** selectively coupled to the output shaft **926**. An example shaft displacement angle **9604** includes: an input angle **9702**, a main box angle **9802** (reference FIG. **62**), and/or an output angle **9804** (reference FIG. **62**). An example input angle **9702** includes an angle value representative of a rotational displacement difference between the input shaft **204** and the countershaft **902**. An example main box angle **9802** includes a rotational displacement difference between the countershaft **902** and the output shaft **926**. An example output angle **9804** includes a rotational displacement difference between the input shaft **204** and the output shaft **926**. It will be recognized that a shaft displacement angle **9604** may additionally or alternatively include a relative angle between any shafts in the transmission, such as an angle between the input shaft **204** and the main shaft **9508**, an angle between the countershaft **902** and the main shaft **9508**, and/or an angle between the main shaft **9508** and the output shaft **926**.

Referencing FIG. **62**, an apparatus **9800** includes the controller **9506** having a zero torque determination circuit **9806** that determines the transmission is operating in a zero torque region **9808** in response to the shaft displacement angle **9604** (including, without limitation, any one or more of the input angle **9702**, main box angle **9802**, and/or output angle **9804**) including a difference value below a zero torque threshold value **9814**. For example, a range of shaft displacement angles **9604** may indicate the shafts are aligned (e.g. at a "zero" angle or other selected convention), and a range of angles near the aligned angle may indicate a backlash region **9810**—for example the space between gear contact on one side of rotation (e.g. driving side) and contact on a second side of the rotation (e.g. coasting side). Determination of that the shaft displacement angle **9604** includes a difference value below the zero torque threshold value **9814** includes at least: determining that the shaft displacement angle **9604** is within a threshold distance of an aligned angle for the shafts; determining that the shaft displacement angle **9604** is within a range of angles defining a backlash region **9810** (e.g. −3 to +3; 0 to 5; −4 to +3, etc.), where the backlash region **9810** depends upon the gear arrangements and construction (e.g. helical gears versus spur gears, manufacturing tolerances, and/or tooth arrangements); determining that the shaft displacement angle **9604** is within a range of angles determined in response to the backlash region **9810** (e.g. slightly larger or smaller than the backlash region **9810** selected based upon desired response, and/or anisotropic to the coast-side contact versus the drive-side contact); determining that the shaft displacement angle **9604** is approaching the backlash region **9810** (e.g. based on the rate of change of the shaft displacement angle **9604** and distance from the backlash region **9810**), and/or any of the preceding operations with a hysteresis applied (e.g. to prevent state cycling, dithering, and/or non-linear or unexpected control operations). Example and non-limiting hysteresis operations applied to the determining the shaft displacement angle **9604** includes a difference value below the zero torque threshold value **9814** include a position based or time based hysteresis, anisotropic hysteresis for coast-side versus driver-side entry or exit of the determination, and/or anisotropic hysteresis for entry versus exit of the determination (e.g. the shaft displacement angle **9604** would otherwise be determined as below the zero torque threshold value **9814** but for the application of the hysteresis, and/or the shaft displacement angle **9604** would otherwise be determined as not below the zero torque threshold value **9814** but for the application of the hysteresis).

In certain embodiments, the zero torque determination circuit **9806** determines that the shafts are in a region exhibiting zero relative torque, about to enter a region exhibiting zero relative torque, have just exited a region exhibiting zero relative torque, and/or are in a region where zero relative torque is a potential imminent operating condition; each of these respective determinations are explicitly contemplated herein, and in certain embodiments each of these determinations, or all of these determinations, may be useful for some purposes (e.g. anticipating a zero torque condition and/or mitigating a risk that may occur if a zero torque condition occurs, where operations to mitigate are low cost, unintrusive, or otherwise more desirable than not responding to the potential zero torque condition), wherein for other purposes one or more of these respective determinations are not valuable and are not present in certain embodiments. One of skill in the art, having the benefit of the disclosures herein and information ordinarily available when contemplating a particular embodiment, can readily determine operations to determine that the shaft displacement angle **9604** includes a difference value below a zero torque threshold value **9814**, and/or that the transmission **100** is operating in a zero torque region **9808**. Non-limiting considerations for determining the zero torque threshold value **9814**, operations to determine whether the transmission **100** is operating in a zero torque region, and/or operations to determine whether the shaft displacement angle **9604** includes a difference value below a zero torque threshold value **9814** include: the time transients of detection of, and response to, operations of the zero torque condition, the type of response contemplated including costs of failing to respond to a zero torque condition, and other considerations that will be understood from the present disclosure regarding various uses of the shaft displacement angle **9604** and detection of a zero torque condition.

The example controller **9506** further includes the zero torque determination circuit **9806** that determines that the transmission **100** is operating in a zero torque region **9808** in response to a difference value of the shaft displacement angle **9604** exhibiting a change in sign. Example operations to determine the difference value of the shaft displacement angle **9604** exhibits a change in sign include, without limitation, determining: a change from above a zero torque point to below the zero torque point, a change from below the zero torque point to above the zero torque point, a change from below an alignment angle to above the alignment angle, a change from above the alignment angle to below the alignment angle, a change from outside a backlash region **9810** to inside a backlash region **9810**, and/or a change from inside the backlash region **9810** to outside the backlash region **9810**. An example controller **9506** further includes a backlash determination circuit **9812** that determines that the transmission **100** is in a backlash region **9810** in response to the shaft displacement angle including a difference value below a zero torque threshold value **9814**; and/or the backlash determination circuit **9812** determining that the transmission **100** is in a backlash region **9810** in response to a difference value of the shaft displacement angle **9604** exhibiting a change in sign.

Referencing FIG. **63**, an example apparatus **9900** includes a controller **9506** further having a torque state description circuit **9902** that determines, in response to the shaft displacement angle **9604**, that the transmission is in one of: a zero torque region **9808** and/or imminently approaching the zero torque region **9808**, and the displacement response circuit **9606** further provides a shift pre-load command **9906** in response to the determining the transmission is in one of the zero torque region **9808** and/or the imminent zero torque region **9904**. Additionally or alternatively, the torque state description circuit **9902** may determine that the transmission is in one of a backlash region **9810** and/or imminently approaching a backlash region **9810**, and the displacement response circuit **9606** provides the shift pre-load command **9906** in response to the backlash region **9810** and/or imminently approaching a backlash region **9810**. Any operations described throughout the present disclosure to determine operation of the transmission in the zero torque region **9808**, the backlash region **9810**, and/or imminently approaching these regions are contemplated herein for embodiments of the torque state description circuit **9902**.

A system **9500** further includes a shift actuator responsive to the shift pre-load command **9906**. An example shift pre-load command **9906** includes a command to pre-load an actuator volume, for example a volume for a pneumatic actuator, where pressure in the actuator volume urges the shift actuator by acting on a pneumatic piston. The example pre-loaded actuator volume urges the shift actuator to a neutral position, and can include pressure on a disengaging side of the shift actuator (e.g. where the shift actuator is engaged in a gear before the determining the zero torque region **9808** and/or imminent zero torque region **9904**), and/or may further include pressure on an engaging side of the shift actuator, such that balanced pressure to return the shift actuator to a neutral position is present. In certain embodiments, the shift actuator corresponds to a gear mesh that is not being shifted during a shift event. An example system further includes a second gear mesh that is being shifted during the shift event is positioned forward in the transmission **100** relative to the gear mesh that is not being shifted. In certain embodiments, the controller **9506** further includes the displacement response circuit **9606** further providing a shift return command **9908**, and where the shift actuator is responsive to the shift return command to return the shift actuator to an engaged position.

In certain embodiments, in response to the shift pre-load command **9906** and the shift return command **9908**, the shift actuator moves the synchronizer and/or gear coupler to the neutral position, and/or the synchronizer and/or gear coupler may be locked in to the gear mesh until the backlash crossing event occurs, whereupon during the zero torque event and/or backlash crossing, the pre-loaded shift actuator will slide the synchronizer and/or gear coupler out of gear, preventing bounce, oscillation, and/or other undesirable behavior during the backlash crossing. Accordingly, the first gear mesh is thereby disengaged during at least a portion of the backlash event. In certain embodiments, a shift event on one gear mesh causes a transient in the transmission, such that another gear mesh that is engaged in gear and is not involved in the shift event causes an oscillation, bounce, noise, or other undesirable performance of the transmission. In certain embodiments, a shift event on a forward gear mesh experiences greater forces and torque transients, increasing the experienced oscillation, bounce, noise, or other undesirable performance of the transmission.

An example system **9500** includes the clutch **106** that selectively decouples a prime mover **9502** from the input shaft **204** of the transmission **100**, a progressive actuator (such as a linear clutch actuator **1002**—reference FIG. **10**) operationally coupled to the clutch **106**, where a position of the progressive actuator **1002** corresponds to a position of the clutch **106**. A controller **9506** includes the displacement response circuit **9606** that further provides a clutch disengage command **9910** in response to the determining the transmission is in one the zero torque region **9808**, imminently approaching the zero torque region **9808**, in the backlash region **9810**, and/or imminently approaching the backlash region **9810**. The example system **9500** includes the progressive actuator **1002** responsive to the clutch disengage command **9910**, where the clutch disengage command **9910** includes a command to perform one of disengaging the clutch and/or slipping the clutch. In certain embodiments, the displacement response circuit **9606** further provides a clutch engage command **9912**, and where the progressive actuator **1002** is responsive to the clutch engage command **9912** to return the clutch to a locked up position.

Additionally or alternatively, the controller **9510** provides a command to disengage a clutch during at least a portion of the backlash crossing event and/or zero torque event, and/or to slip the clutch (e.g. reduce clutch engagement torque until the clutch is not in lock-up) during at least a portion of the backlash crossing event and/or zero torque event. The disengagement and/or slipping of the clutch mitigates the torsional forces experienced during the backlash event, allowing the gear mesh to settle on the other side of the backlash (e.g. from drive side to coast side engagement, or from coast side to drive side engagement) without experiencing negative consequences to smooth operation of the transmission **100**, noticeable effects by the driver or operator, and/or mitigating these.

Referencing FIG. **64**, an apparatus **10000** includes a controller **9506** having a shaft displacement circuit **9602** that interprets a shaft displacement angle **9604**. The controller **9506** further includes a torque input determination circuit **10002** that determines a prime mover torque value **10004** in response to the shaft displacement angle **9604**. In certain embodiments, the torque input determination circuit **10002** further determines when a prime mover torque value **10004** is zero—for example when the shaft displacement angle **9604** is consistent with a lack of net torsional force at the prime mover **9502**. The controller **9506** further includes a displacement response circuit **9606** that provides a gear disengage command **10006** in response to the prime mover torque value **10004**. A system **9500** further includes a shift actuator responsive to the gear disengage command **10006**. In certain embodiments, the controller **9506** includes the displacement response circuit **9606** that provides, in response to the prime mover torque value **10004**, a prime mover torque pulse command **10008** and/or a clutch modulation command **10010**. In certain embodiments, where the prime mover torque value **10004** is low, experiencing a zero value, and/or where a torque transition occurs that causes the transmission gear alignments to switch from driving to coast and/or coasting to driving, the controller **9506** can predict that a backlash crossing event will occur in future operating conditions. Accordingly, the displacement response circuit **9606** can request a prime mover torque pulse command **10008** (e.g. to switch the transmission gear alignments from coasting to driving side), and/or a clutch modulation command **10010** to switch the transmission gear alignments. In certain embodiments, the controller **9506** includes a gear mesh orientation circuit **10012** that determines a gear mesh orientation **10014** in response to the shaft displacement angle **9604**—for example to determine whether the transmission gear alignment is on the drive side or the coast side. An example controller **9506** further includes the displacement response circuit **9606** that determines that the gear mesh orientation **10014** is opposite a post-shift gear mesh orientation **10016** for an impending shift event, and in certain embodiments, in response to the gear mesh orientation **10014** being opposite the post-shift gear mesh orientation **10016**, provides at least one command such as: a prime mover torque pulse command **10008**, a clutch modulation command **10010**, and/or a shift timing adjustment command **10018**. An example shift timing adjustment command **10018** delays a shift until a gear mesh orientation change is completed, delays a shift based on predicted conditions that will switch the gear mesh orientation change before the shift is needed, and/or delays a shift based on predicted conditions that will mitigate the effect of a backlash crossing that are predicted to occur before the shift is needed (for example a changing torque value of the prime mover and/or a changing vehicle speed to a more desirable condition).

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and at least one set of drive gears having teeth with substantially flat tops to improve at least one of noise and efficiency. In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and an integrated mechanical assembly with a common air supply for both shift actuation and clutch actuation for the transmission.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and a having at least one helical gear set to reduce noise.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear, where the gears have teeth that are configured to engage with a sliding velocity of engagement that provides high efficiency.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having enclosure bearings and gear sets configured to reduce noise from the transmission.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having a mechanically and electrically integrated assembly configured to be mounted on the transmission, wherein the assembly provides gear shift actuation and clutch actuation.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having wormwheel-ground gear teeth having a tooth profile that is designed to provide efficient interaction of the gears.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having three gear systems having three, three and two modes of engagement respectively for providing an 18 speed transmission.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having a three-by-three-by-two gear set architecture.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear; low contact ratio gears; bearings to reduce the impact of thrust loads on efficiency; and a low loss lubrication system.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having an integrated assembly that includes a linear clutch actuator, at least one position sensor, and valve banks for gear shift and clutch actuation.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having a pneumatic, linear clutch actuation system that is configured to hold substantially no volume of unused air.

In embodiments, an automated truck transmission is provided, using a plurality of high speed countershafts that are configured to be mechanically coupled to the main drive shaft by a plurality of gears when the transmission is in gear and having at least one power take-off (PTO) interface that has an aluminum enclosure and a gear set that is optimized for a specified use of the PTO.

In embodiments, an automated truck transmission may have various enclosures, such as for separating various gear boxes, such as in a 3×2×2 gear box architecture. The enclosures may have bearings, and in embodiments, the enclosure bearings may be configured to be isolated from the thrust loads of the transmission. For example, in embodiments an automatic truck transmission architecture is provided where one or more of the enclosure bearings take radial separating loads, and the thrust reaction loads are substantially deployed on other bearings (not the enclosure bearings).

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and a common air supply that is used for gear shift actuation and for clutch actuation for the transmission.

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and wherein the automated truck transmission has at least one set of drive gears having teeth with substantially flat tops to improve at least one of noise and efficiency.

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and wherein a helical gear set is provided to reduce noise.

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and wherein the transmission has wormwheel-ground gear teeth having a tooth profile that is designed to provide efficient interaction of the gears.

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and wherein the transmission has three gear systems having three, three and two modes of engagement respectively for providing an 18 speed transmission.

In embodiments, an automatic truck transmission architecture is provided wherein enclosure bearings take radial separating loads, wherein thrust reaction loads are deployed on other bearings and wherein the transmission has a three-by-three-by-two gear set architecture.

In embodiments, an automatic truck transmission architecture is provided having enclosure bearings that take radial separating loads, having thrust reaction loads that are deployed on other bearings and having a pneumatic, linear clutch actuation system that is configured to hold substantially no volume of unused air.

In embodiments, an automatic truck transmission architecture is provided having enclosure bearings that take radial separating loads, having thrust reaction loads that are deployed on other bearings and having a plurality of power take-off (PTO) interfaces.

In embodiments, an automated truck transmission is provided, having at least one set of drive gears that has teeth with substantially flat tops to improve at least one of noise and efficiency and having an integrated mechanical assembly with a common air supply for both shift actuation and clutch actuation for the transmission.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein a helical gear set is provided to reduce noise.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops configured to engage with a sliding velocity of engagement that provides high efficiency.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein enclosure bearings and gear sets are configured to reduce noise from the transmission.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has a mechanically and electrically integrated assembly configured to be mounted on the transmission, wherein the assembly provides gear shift actuation and clutch actuation.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wormwheel-ground gear teeth having a tooth profile that is designed to provide efficient interaction of the gears.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has three gear systems having three, three and two modes of engagement respectively for providing an 18 speed transmission.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency of at least one gear set in a three-by-three-by-two gear set architecture.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has low contact ratio gears, bearings to reduce the impact of thrust loads on efficiency and a low loss lubrication system.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has a linear clutch actuator that is integrated with the shift actuation system for the transmission.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has a hoseless pneumatic actuation system for at least one of clutch actuation and gear shift actuation.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has a centralized actuation system wherein the same assembly provides clutch actuation and gear shift actuation.

In embodiments, an automated truck transmission is provided, wherein at least one set of drive gears has teeth with substantially flat tops to improve at least one of noise and efficiency and wherein the transmission has a pneumatic, linear clutch actuation system that is configured to hold substantially no volume of unused air.

In embodiments, an automated truck transmission is provided having an integrated mechanical assembly with a common air supply that is used for both gear shift actuation and clutch actuation and three gear systems having three, three and two modes of engagement respectively for providing an 18 speed transmission.

In embodiments, an automated truck transmission is provided having an integrated mechanical assembly with a common air supply that is used for both gear shift actuation and clutch actuation and having a three-by-three-by-two gear set architecture.

In embodiments, an automated truck transmission is provided having an integrated mechanical assembly with a common air supply that is used for both gear shift actuation and clutch actuation and having low contact ratio gears, bearings to reduce the impact of thrust loads on efficiency and a low loss lubrication system.

Various embodiments disclosed herein may include an aluminum automated truck transmission, wherein a helical gear is used for at least one gear set of the transmission to reduce noise from the transmission. A helical gear set may be used in combination with various other methods, systems and components of an automated truck transmission disclosed throughout this disclosure, including the following.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a set of substantially circular gears with teeth that are configured to engage with a sliding velocity of engagement that provides high efficiency.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having enclosure bearings and gear sets configured to reduce noise from the transmission.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a mechanically and electrically integrated assembly configured to be mounted on the transmission, wherein the assembly provides gear shift actuation and clutch actuation.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having wormwheel-ground gear teeth having a tooth profile that is designed to provide efficient interaction of the gears.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having three gear systems having three, three and two modes of engagement respectively for providing an 18 speed transmission.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a three-by-three-by-two gear set architecture.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having low contact ratio gears, bearings to reduce the impact of thrust loads on efficiency and a low loss lubrication system.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a linear clutch actuator that is integrated with the shift actuation system for the transmission.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having an integrated assembly that includes a linear clutch actuator, at least one position sensor, and valve banks for gear shift and clutch actuation.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a hoseless pneumatic actuation system for at least one of clutch actuation and gear shift actuation.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a gear system configured to have bearings accept thrust loads to improve engine efficiency.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a centralized actuation system wherein the same assembly provides clutch actuation and gear shift actuation.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a pneumatic, linear clutch actuation system that is configured to hold substantially no volume of unused air.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having a plurality of power take-off (PTO) interfaces.

In embodiments, an aluminum automated truck transmission is provided, having a helical gear as set as at least one gear set of the transmission to reduce noise from the transmission and having at least one power take-off (PTO) interface that has an aluminum enclosure and a gear set that is optimized for a specified use of the PTO.

In embodiments, an automated truck transmission is provided, wherein the gear set comprises a plurality of substantially circular gears having teeth that are configured to engaged during at least one operating mode of the automated truck transmission, configuring the shape of the teeth of the gears based on the sliding velocity of engagement of the teeth top provide improved efficiency of the automated truck transmission. Embodiments with gear teeth optimized based on sliding velocity may be used in combination with various other methods, systems and components of an overall architecture for an efficient, low noise transmission, including as follows.

Embodiments of the present disclosure include ones for a die cast aluminum automatic truck transmission is provided, wherein the enclosure bearings and gear sets are configured to reduce noise from the transmission. Such a noise-reduced configuration can be used in combination with other methods, systems and components of an automatic truck transmission architecture as described throughout the present disclosure.

In embodiments, a die cast aluminum automatic truck transmission is provided, having enclosure bearings and gear sets configured to reduce noise from the transmission and having low contact ratio gears, bearings to reduce the impact of thrust loads on efficiency and a low loss lubrication system.

In embodiments, a die cast aluminum automatic truck transmission is provided, having enclosure bearings and gear sets configured to reduce noise from the transmission and having a linear clutch actuator that is integrated with the shift actuation system for the transmission.

In embodiments, a die cast aluminum automatic truck transmission is provided, having enclosure bearings and gear sets configured to reduce noise from the transmission and having an integrated assembly that includes a linear clutch actuator, at least one position sensor, and valve banks for gear shift and clutch actuation.

In embodiments, a die cast aluminum automatic truck transmission is provided, having enclosure bearings and gear sets configured to reduce noise from the transmission and having a gear system configured to have bearings accept thrust loads to improve engine efficiency.

In embodiments, a die cast aluminum automatic truck transmission is provided, having enclosure bearings and gear sets configured to reduce noise from the transmission and having a centralized actuation system wherein the same assembly provides clutch actuation and gear shift actuation.

In embodiments, an automated truck transmission is provided, wherein the bearings for the gears are configured to reduce or cancel thrust loads when the drive shaft is engaged. Such an architecture may be used in combination with various other methods, systems and components described throughout this disclosure, including as follows.

In embodiments, an automated truck transmission is provided having a gear system configured to having bearings accept thrust loads to improve engine efficiency and having a centralized actuation system wherein the same assembly provides clutch actuation and gear shift actuation.

In embodiments, an automated truck transmission is provided having a gear system configured to having bearings accept thrust loads to improve engine efficiency and having a pneumatic, linear clutch actuation system that is configured to hold substantially no volume of unused air.

In embodiments, an automated truck transmission is provided having a gear system configured to having bearings accept thrust loads to improve engine efficiency and having a plurality of power take-off (PTO) interfaces.

In embodiments, an automated truck transmission is provided having a gear system configured to having bearings accept thrust loads to improve engine efficiency and having at least one power take-off (PTO) interface that has an aluminum enclosure and a gear set that is optimized for a specified use of the PTO.

In embodiments, an automated truck transmission is provided, wherein the transmission has a plurality of power take-off (PTO) interfaces. Such an architecture may be used in combination with various other methods, systems and components described throughout this disclosure, including as follows. In embodiments, an automated truck transmission is provided having a plurality of power take-off (PTO) interfaces and having at least one power take-off (PTO) interface that has an aluminum enclosure and a gear set that is optimized for a specified use of the PTO.

In embodiments, an automated truck transmission is provided, wherein the transmission has at least one power take-off (PTO) interface with an aluminum enclosure and an optimized gear set. Such an architecture may be used in combination with various other methods, systems and components described throughout this disclosure.

While only a few embodiments of the present disclosure have been shown and described, it will be obvious to those skilled in the art that many changes and modifications may be made thereunto without departing from the spirit and scope of the present disclosure as described in the following claims. All patent applications and patents, both foreign and domestic, and all other publications referenced herein are incorporated herein in their entireties to the full extent permitted by law.

Any one or more of the terms computer, computing device, processor, circuit, and/or server include a computer of any type, capable to access instructions stored in communication thereto such as upon a non-transient computer readable medium, whereupon the computer performs operations of systems or methods described herein upon executing the instructions. In certain embodiments, such instructions themselves comprise a computer, computing device, processor, circuit, and/or server. Additionally or alternatively, a computer, computing device, processor, circuit, and/or server may be a separate hardware device, one or more computing resources distributed across hardware devices, and/or may include such aspects as logical circuits, embedded circuits, sensors, actuators, input and/or output devices, network and/or communication resources, memory resources of any type, processing resources of any type, and/or hardware devices configured to be responsive to determined conditions to functionally execute one or more operations of systems and methods herein.

The methods and systems described herein may be deployed in part or in whole through network infrastructures. The network infrastructure may include elements such as computing devices, servers, routers, hubs, firewalls, clients, personal computers, communication devices, routing devices and other active and passive devices, modules, and/or components as known in the art. The computing and/or non-computing device(s) associated with the network infrastructure may include, apart from other components, a storage medium such as flash memory, buffer, stack, RAM, ROM and the like. The methods, program code, instructions, and/or programs described herein and elsewhere may be executed by one or more of the network infrastructural elements.

The methods, program code, instructions, and/or programs may be stored and/or accessed on machine readable transitory and/or non-transitory media that may include: computer components, devices, and recording media that retain digital data used for computing for some interval of time; semiconductor storage known as random access memory (RAM); mass storage typically for more permanent storage, such as optical discs, forms of magnetic storage like hard disks, tapes, drums, cards and other types; processor registers, cache memory, volatile memory, non-volatile memory; optical storage such as CD, DVD; removable media such as flash memory (e.g., USB sticks or keys), floppy disks, magnetic tape, paper tape, punch cards, standalone RAM disks, Zip drives, removable mass storage, off-line, and the like; other computer memory such as dynamic memory, static memory, read/write storage, mutable storage, read only, random access, sequential access, location addressable, file addressable, content addressable, network attached storage, storage area network, bar codes, magnetic ink, and the like.

Certain operations described herein include interpreting, receiving, and/or determining one or more values, parameters, inputs, data, or other information. Operations including interpreting, receiving, and/or determining any value parameter, input, data, and/or other information include, without limitation: receiving data via a user input; receiving data over a network of any type; reading a data value from a memory location in communication with the receiving device; utilizing a default value as a received data value; estimating, calculating, or deriving a data value based on other information available to the receiving device; and/or updating any of these in response to a later received data value. In certain embodiments, a data value may be received by a first operation, and later updated by a second operation, as part of the receiving a data value. For example, when communications are down, intermittent, or interrupted, a first operation to interpret, receive, and/or determine a data value may be performed, and when communications are restored an updated operation to interpret, receive, and/or determine the data value may be performed.

Certain logical groupings of operations herein, for example methods or procedures of the current disclosure, are provided to illustrate aspects of the present disclosure. Operations described herein are schematically described and/or depicted, and operations may be combined, divided, re-ordered, added, or removed in a manner consistent with the disclosure herein. It is understood that the context of an operational description may require an ordering for one or more operations, and/or an order for one or more operations may be explicitly disclosed, but the order of operations should be understood broadly, where any equivalent grouping of operations to provide an equivalent outcome of operations is specifically contemplated herein. For example, if a value is used in one operational step, the determining of the value may be required before that operational step in certain contexts (e.g. where the time delay of data for an operation to achieve a certain effect is important), but may not be required before that operation step in other contexts (e.g. where usage of the value from a previous execution cycle of the operations would be sufficient for those purposes). Accordingly, in certain embodiments an order of operations and grouping of operations as described is explicitly contemplated herein, and in certain embodiments re-ordering, subdivision, and/or different grouping of operations is explicitly contemplated herein.

The methods and systems described herein may transform physical and/or or intangible items from one state to another. The methods and systems described herein may also transform data representing physical and/or intangible items from one state to another.

The elements described and depicted herein, including in flow charts, block diagrams, and/or operational descriptions, depict and/or describe specific example arrangements of elements for purposes of illustration. However, the depicted and/or described elements, the functions thereof, and/or arrangements of these, may be implemented on machines, such as through computer executable transitory and/or non-transitory media having a processor capable of executing program instructions stored thereon, and/or as logical circuits or hardware arrangements. Furthermore, the elements described and/or depicted herein, and/or any other logical components, may be implemented on a machine capable of executing program instructions. Thus, while the foregoing flow charts, block diagrams, and/or operational descriptions set forth functional aspects of the disclosed systems, any arrangement of program instructions implementing these functional aspects are contemplated herein. Similarly, it will be appreciated that the various steps identified and described above may be varied, and that the order of steps may be adapted to particular applications of the techniques disclosed herein. Additionally, any steps or operations may be divided and/or combined in any manner providing similar functionality to the described operations. All such variations and modifications are contemplated in the present disclosure. The methods and/or processes described above, and steps thereof, may be implemented in hardware, program code, instructions, and/or programs or any combination of hardware and methods, program code, instructions, and/or programs suitable for a particular application. Example hardware includes a dedicated computing device or specific computing device, a particular aspect or component of a specific computing device, and/or an arrangement of hardware components and/or logical circuits to perform one or more of the operations of a method and/or system. The processes may be implemented in one or more microprocessors, microcontrollers, embedded microcontrollers, programmable digital signal processors or other programmable device, along with internal and/or external memory. The processes may also, or instead, be embodied in an application specific integrated circuit, a programmable gate array, programmable array logic, or any other device or combination of devices that may be configured to process electronic signals. It will further be appreciated that one or more of the processes may be realized as a computer executable code capable of being executed on a machine readable medium.

The computer executable code may be created using a structured programming language such as C, an object oriented programming language such as C++, or any other high-level or low-level programming language (including assembly languages, hardware description languages, and database programming languages and technologies) that may be stored, compiled or interpreted to run on one of the above devices, as well as heterogeneous combinations of processors, processor architectures, or combinations of different hardware and computer readable instructions, or any other machine capable of executing program instructions.

Thus, in one aspect, each method described above and combinations thereof may be embodied in computer executable code that, when executing on one or more computing devices, performs the steps thereof. In another aspect, the methods may be embodied in systems that perform the steps thereof, and may be distributed across devices in a number of ways, or all of the functionality may be integrated into a dedicated, standalone device or other hardware. In another aspect, the means for performing the steps associated with the processes described above may include any of the hardware and/or computer readable instructions described above. All such permutations and combinations are contemplated in embodiments of the present disclosure.

The use of the terms “a” and “an” and “the” and similar referents in the context of describing the disclosure (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the disclosure and does not pose a limitation on the scope of the disclosure unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the disclosure.

It will be appreciated that the methods and systems described are set forth by way of example and not of limitation. Numerous variations, additions, omissions, and other modifications will be apparent to one of ordinary skill in the art. In addition, the order or presentation of method steps in the description and drawings above is not intended to require this order of performing the recited steps unless a particular order is expressly required or otherwise clear from the context. Thus, while particular embodiments have been shown and described, it will be apparent to those skilled in the art that various changes and modifications in form and details may be made therein without departing from the spirit and scope of this disclosure and are intended to form a part of the invention as defined by the following claims, which are to be interpreted in the broadest sense allowable by law.

What is claimed is:

1. A system, comprising:

a transmission comprising an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing a torque output to a driveline; and

a controller comprising:

a shaft displacement circuit structured to interpret a shaft displacement angle, the shaft displacement angle comprising an angle value representative of a rotational displacement difference between at least two shafts;

a shift state description circuit structured to determine that a synchronizer is unblocked in response to the angle value;

a displacement response circuit structured to provide a shift engagement command in response to the determining the synchronizer is unblocked; and

a shift actuator responsive to the shift engagement command.

2. The system of claim 1, further comprising:

the transmission further comprising a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end; and

wherein the shaft displacement angle comprises an input angle, wherein the input angle comprises an angle value representative of the rotational displacement difference between the input shaft and the countershaft.

3. The system of claim 2, wherein the controller further comprises a shift actuation circuit further structured to provide a shift opposition command in response to the determining the synchronizer is unblocked, and wherein the shift actuator is further responsive to the shift opposition command.

4. The system of claim 3, wherein the shift engagement command comprises an increased actuation pressure relative to a decreased actuation pressure applied during a synchronization operation.

5. The system of claim 3, wherein the shift opposition command comprises an increased opposition pressure to a movement of the shift actuator relative to a synchronization opposition pressure, the synchronization opposition pressure comprising an opposition pressure during at least one of a synchronization operation or a synchronizer approach operation.

6. The system of claim 5, wherein the increased opposition pressure comprises an amount of opposition pressure selected to reduce a final engagement velocity of the shift actuator.

7. The system of claim 1, wherein the shift state description circuit is further structured to determine the synchronizer is unblocked in response to a rate of change of the input angle.

8. The system of claim 7, wherein the shift state description circuit is further structured to determine the synchronizer is unblocked in response to the rate of change of the input angle transitioning from a first rate of change to a second rate of change, wherein the first rate of change is associated with a synching position of the shift actuator, and wherein the second rate of change is associated with synchronizer unblock position of the shift actuator.

9. A system, comprising:

a transmission comprising:

an input shaft and an output shaft, the input shaft selectively accepting a torque input from a prime mover, and the output shaft selectively providing a torque output to a driveline;

a countershaft selectively coupled to the input shaft at a first end, and selectively coupled to the output shaft at a second end;

wherein the countershaft is selectively coupled to the output shaft at the second end via a main shaft selectively coupled to the output shaft; and

a controller comprising:

a shaft displacement circuit structured to interpret a shaft displacement angle, the shaft displacement angle comprising an angle value representative of a rotational displacement difference between at least two shafts of the transmission, and wherein the shaft displacement angle comprises at least one angle selected from the angles consisting of:

an input angle comprising an angle value representative of a rotational displacement difference between the input shaft and the countershaft;

a main box angle comprising a rotational displacement difference between the countershaft and the output shaft;

an output angle comprising a rotational displacement difference between the input shaft and the output shaft; and

a torque input determination circuit structured to determine a prime mover torque value in response to the shaft displacement angle and

a displacement response circuit structured to provide, in response to the prime mover torque value, a prime mover torque pulse command to alter gear mesh orientation.

10. The system of claim 9, wherein the torque input determination circuit is further structured to determine when the prime mover torque value is zero.

11. The system of claim 9, wherein the displacement response circuit is further structured to provide a gear disengage command in response to the prime mover torque value, and wherein the system further comprises a shift actuator responsive to the gear disengage command.

12. The system of claim 9, wherein the displacement response circuit is further structured to provide, in response to the prime mover torque value, at least one of a prime mover torque pulse command or a clutch modulation command.

13. An apparatus, comprising:

a shaft displacement circuit structured to interpret a shaft displacement angle, the shaft displacement angle comprising an angle value representative of a rotational displacement difference between at least two shafts of a transmission;

a shift state description circuit structured to determine that a synchronizer is unblocked in response to the angle value; and

a displacement response circuit structured to provide a shift engagement command in response to the determining the synchronizer is unblocked.

14. The apparatus of claim 13, further comprising a torque input determination circuit structured to determine a prime mover torque value in response to the shaft displacement angle.

15. The apparatus of claim 14, wherein the torque input determination circuit is further structured to determine when the transmission is in one of a zero torque region or an imminent zero torque region.

16. The apparatus of claim 15, wherein the displacement response circuit is further structured to provide a shift pre-load command in response to the determining the transmission is in one of the zero torque region or the imminent zero torque region.

17. The apparatus of claim 14, wherein the displacement response circuit is further structured to provide, in response to the prime mover torque value, a prime mover torque pulse command.

18. The apparatus of claim 17, wherein the torque input determination circuit is further structured to determine when the transmission is in one of a zero torque region or an imminent zero torque region, and wherein the displacement response circuit is further structured to provide the prime mover torque pulse command in response to the one of the zero torque region or the imminent zero torque region.

19. The apparatus of claim 13, the shift state description circuit is further structured to determine a synchronizer is unblocked in response to a rate of change of shaft displacement angle transitioning from a first rate of change to a second rate of change, wherein the first rate of change is

associated with a synching position of a shift actuator, and wherein the second rate of change is associated with synchronizer unblock position of the shift actuator.

20. The apparatus of claim **13**, further comprising a shift actuation circuit structured to provide a shift opposition command in response to the determining the synchronizer is unblocked, and wherein a shift actuator is further responsive to the shift opposition command.

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